THE

JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MAY 1913

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SPRING MEETING: BALTIMORE, MAY 20-23.
MEETING IN GERMANY: JUNE 21-JULY 8

"I FURTHERMORE AGREE TO PROMOTE THE OBJECTS OF THE SOCIETY AS FAR AS SHALL BE IN MY POWER"

The above is an extract from the agreement signed by every member upon acceptance of membership in the Society.

In a little over one year the Committee on Increase of Membership has, with the assistance of about 15 per cent of the members, increased the number of members by over 25 per cent, and yet engineers of highest attainment only were invited. At the Spring Meeting the total membership will be over five thousand. But "*the Society of the industries*," with its broad field, should have a membership of at least ten thousand among the influential men in the several industries. The solution of how to obtain "the other half" is simple if the members will respond to this announcement as they should. If every member will secure the membership of the most eminent engineer of his acquaintance not already a member, the object will be accomplished. But as it would scarcely be possible that *every* member could do this, we ask that all who can send a list of those he deems qualified to meet the strict requirements of membership.

If the members will submit for Members grade lists of qualified engineers and for Associate grade those competent to coöperate with engineers in the advancement of professional knowledge, the Committee will be pleased to take up the matter at that point and supply those who are suggested with complete information.

COMMITTEE ON INCREASE OF MEMBERSHIP

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Michigan, H. W. Alden	*Seattle*, R. M. Dyer

COMING MEETINGS OF THE SOCIETY

May 20–23, *Baltimore, Md.*, Spring Meeting. Headquarters, Hotel Belvedere. See Program on page 3.

June 21—*July* 8, Joint Meeting with Verein deutscher Ingenieure, Leipzig, and various industrial cities of Germany. See page 7 for Tentative Program.

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OF

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 MAY 1913 NUMBER 5

The Society wishes to secure copies of the following issues of The Journal: August 1911, September 1911, October 1911, January 1912. These will be purchased at 25 cents apiece, provided they are in good condition.

SPRING MEETING

The program for the Spring Meeting at Baltimore, May 20-23, is published in this number, with information regarding railroad transportation. The headquarters will be at the Hotel Belvedere and the professional sessions and various social functions will both be held there.

The Society is fortunate in visiting Baltimore at a time when there are features in the way of engineering work of unusual interest. The high-pressure fire system recently completed will be shown to the visitors and a demonstration given of its possibilities in throwing large volumes of water. One of the important excursions will be over the Jones Falls conduits to inspect the newly completed sewage system and the sewage disposal plant at Back River, which is believed to be the largest and one of the most modern in the world. These engineering features, in addition to the natural attractions of the city, the opportunity for a sail in the harbor and for an all-day excursion to Annapolis, promise an occasion of rare enjoyment.

In accordance with the policy recently adopted by the Society,

the visiting members will share in the expense of the entertainment to the extent of paying for their fares, luncheons, and similar expenditures, rather than burdening local members with the necessity of raising funds for these purposes.

HOTEL RESERVATIONS

As it is confidently expected that there will be a large attendance at the meeting, it is very urgent that members should make their hotel reservations early. At this time of year there are always many visitors in Baltimore and accommodations are apt to be in demand. These reservations must be made personally in every instance, direct to the hotel.

Besides the Belvedere, accommodations may be secured in the Stafford, which is only three and a half blocks away from headquarters, and the Hotel Emerson, requiring an eight-minute ride on the trolley.

PROGRAM

Tuesday, May 20

Registration at Headquarters, Hotel Belvedere

Tuesday Evening

Membership Reunion and Informal Reception

Wednesday, May 21

Business Meeting, 9.30 a.m.

Business meeting. Report of tellers of election of members. Announcement of ballot on amendments to the Constitution relating to membership grades. New business may be presented at this session.

Reports of special committees on Myriawatt, Involute Gears, Standardization of Catalogues, Code of Ethics and National Museum

SIMULTANEOUS SESSIONS FOLLOWING BUSINESS MEETING

Professional Session

TEST OF A HYDRAULIC BUFFER, Carl Schwartz

THE PRESENT CONDITION OF THE PATENT LAW, Edwin J. Prindle

SHADING IN MECHANICAL DRAWING, Theodore W. Johnson

COST OF UPKEEP OF HORSE-DRAWN VEHICLES AGAINST ELECTRIC VEHICLES, W. R. Metz

Gas Power Session

Business meeting

PRESENT OPERATION OF GAS ENGINES USING BLAST-FURNACE GAS AS FUEL, Charles C. Sampson

Wednesday Afternoon

Demonstration of the high-pressure fire system at City Hall Plaza, and inspection of pumping station, followed by a sail about the harbor to inspect the water front, shipping facilities, and other features of interest

Wednesday Evening

Lecture, illustrated by lantern views: Around the World in Eighty Minutes, by Hon. O. P. Austin, Secretary, National Geographic Society

Thursday, May 22

Fire Protection Session, 9.30 a.m.

The Baltimore High-Pressure Fire Service, James B. Scott

National Standard Hose Couplings and Hydrant Fittings for Public Fire Service, F. M. Griswold

Debarment of City Conflagrations, Albert Blauvelt

Allowable Height and Area in Factory Buildings, Ira H. Woolson

The Protection of Main Belt Drives with Fire Retardant Partitions, C. H. Smith

The Life Hazard in Crowded Buildings due to Inadequate Exits, H. F. J. Porter

Thursday Afternoon

Inspection of sewage pumping plant, Jones Falls' conduits, and trip by trolley to sewage disposal plant at Back River

Automobile trip for ladies, about the city and suburbs, with tea served at the Country Club

Thursday Evening

Reception and dance. The Society will be the guest of the Engineers Club of Baltimore on this occasion

Friday, May 23

All day excursion to Annapolis, the capitol of Maryland, and to the U. S. Naval Academy, with a reception by Governor Goldsborough at the State House. After the reception the party will proceed to the Assembly Chamber where Admiral H. I. Cone, engineer-in-chief of the Bureau of Steam Engineering, U. S. N., will deliver an address upon the United States Experimental Station at Annapolis.

Luncheon will be served at the Carvel House. In the afternoon, there will be a band concert by the Naval Academy Band, and a dress parade at 6 o'clock, which may be witnessed by those finding it convenient to remain. It is expected that there will be hydroaeroplane flights by officers and men of the aviation school, and evolutions of the submarine boats stationed at Annapolis.

RAILROAD TRANSPORTATION NOTICE

Special concessions have been secured for members and guests attending the Spring Meeting in Baltimore, May 20-23, 1913.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between May 16-22 inclusive. At the same time request a certificate, *not a receipt*. This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Ask your station agent

whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate at the registration desk. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after May 23.

d An agent of the Trunk Line Association will validate certificates, May 21 and 22. No refund of fare will be made on account of failure to have certificate validated.

e One hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to May 27, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:

The Trunk Line Association including:

All of New York east of a line running from Buffalo to Salamanca; all of Pennsylvania east of the Ohio River; all of New Jersey, Delaware and Maryland; also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville and Washington, D. C.

The New England Passenger Association (except via Bangor and Aroostook R. R. and Eastern Steamship Co.), including:

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, and that portion of New York east of a line running through Poughkeepsie and Troy.

MEETING IN GERMANY 1913

The official party for the trip to Germany, June 21–July 8, is now almost complete, all the ladies' reservations having been made and nearly all the members' reservations being taken. Committees have been appointed to care for various details in connection with the trip and plans are going forward smoothly.

Invitations have been received from a number of cities and firms which will make it possible for members who may so desire to extend their trip through Germany beyond the time scheduled on the official program. Among these are the city of Aachen, of historical as well as industrial interest, with its technical school and seismological station, metallurgical works, and textile and needle manufactures; the city of Freiburg-im-Breisgau, a trading center for the Black Forest, having considerable manufactures and a fine cathedral and university; and also the Prussian city of Breslau, one of Germany's chief commercial centers, containing numerous points of general interest. The Actiengesellschaft Ferrum of Zawodzie bei Kattowitz have also offered their hospitality.

Attention is called to the fact that it is expected that the ladies will participate in all the excursions in Hamburg, particularly the inspection of the port, shipbuilding yard, and Elbe tunnel. On the afternoon of Saturday, June 21, arrangements will be made for the ladies to visit the famous Hagenbeck Zoological Gardens in Stellingen near Hamburg. This is an addition to program as previously announced and as given herewith.

TENTATIVE PROGRAM

NEW YORK

Tuesday, June 10

10.00 a. m. The party sails on the Hamburg-American S. S. Victoria Luise (remodeled "Deutschland") from Hoboken. It will be advisable for members of the party to reach New York not later than June 9.

Representatives of the Verein deutscher Ingenieure will come on board at Cherbourg to receive the visitors.

HAMBURG

Thursday, June 19

Arrival in Hamburg.

Friday, June 20

11.00 a. m. Address: The Hamburg Harbor
11.00 a. m. to 1.00 p. m. Trip around the harbor
5.30 p. m. Reception in the Municipal Hall by the Senate of the city and by the Hamburg Section of the Verein deutscher Ingenieure

Saturday, June 21

10.00 a. m. Excursions
Group 1: Inspection of the Elbe tunnel and visit to the shipyards of Blohm and Voss
Group 2: Visit to the Vulcan yards and inspection of the Elbe tunnel

Sunday, June 22

10.00 a. m. Departure for Leipzig

LEIPZIG

Sunday, June 22

4.30 p. m. Arrival in Leipzig
8.00 p. m. Reception in the Crystal Palace

Monday, June 23

10.00 a. m. Formal meeting in the Municipal Hall
5.00 p. m. Concert under the direction of Mr. Arthur Nikisch in the Gewandhaus
7.30 p. m. Formal dinner in Central Theater

Itinerary of Official Tour in Germany

Tuesday, June 24

9.30 a. m.	Scientific Lectures in the lecture room of the Architectural Exhibition
4.30 p. m.	Inspection of the Monument of the Battle of Nations in commemoration of 100th anniversary of the battle of Leipzig, 1813
8.00 p. m.	Festival in the Palm Garden

Wednesday, June 25

9.10 a. m.	Departure for Dresden

DRESDEN

Wednesday, June 25

11.00 a. m.	Arrival in Dresden
2.00 p. m.	Gather at the Belvedere; automobile trip to the Saxon Switzerland (Bastei), walk to Rathen, by steamer to Pirna, by automobile to Dresden
8.30 p. m.	Reception in the Municipal Building, tendered by the city of Dresden

Thursday, June 26

9.30 a. m.	Excursion through Dresden Group 3: Machine Laboratory of the Technical High School Group 4: Seidel & Naumann Sewing Machine and Bicycle Factory . Group 5: Picture Gallery
12.30 p. m.	Lunch in the Neustadt railway terminal
2.00 p. m.	Departure for Berlin

BERLIN

Thursday, June 26

5.00 p. m.	Arrival in Berlin
8.00 p. m.	Reception in the Reichstag Building

Friday, June 27

9.30 a. m.	Excursions Group 6: Allgemeine-Elektricitäts Gesellschaft Group 7: Siemens-Schuckert Works Group 8: Bergmann Electrical Company Group 9: Ludwig Loewe Company, Machine Tool Factory Group 10: A. Borsig Locomotive Works in Berlin-Tegel Group 11: Ladies' excursion and lunch
8.00 p. m.	Formal dinner in the Zoological Garden

Saturday, June 28

2.30 p. m.	Automobile trip to Potsdam and steamer trip on the Havel
7.00 p. m.	Entertainment by the Berlin Local Section in Wannsee

Sunday, June 29

8.00 a. m.	Departure for Düsseldorf, Rhine-Westphalia

DÜSSELDORF

Sunday, June 29

6.00 p. m. Arrival in Düsseldorf

8.00 p. m. Reception in the City Hall tendered by the city of Düsseldorf

Monday, June 30

9.00 a. m. Excursions

Group 12: Duisburg works of the German Machine Works Company (50 participants)

Group 13: Friedrich-Alfred steel plant of the Friedr. Krupp Co. in Rheinhausen (75 participants)

Group 14: Machine Works of Thyssen & Co. in Mulhheim (Ruhr) (20 participants)

Group 15: Gutehoffnung Steel Plant, Oberhausen Rheinland (40 participants)

Group 16: Rhein Steel Works, Duisburg-Meiderich (50 participants)

Group 17: In the morning the ladies inspect the city of Düsseldorf, and in the evening the welfare activities of Friedr. Krupp Co. in Essen

Group 18: Afternoon inspection of the Duisburg-Ruhrort harbor by the members of groups 12 to 16, as well as others who apply for it

The other visitors will be afforded an opportunity to see the city of Düsseldorf

8.00 p. m. Banquet in the city concert hall of Düsseldorf, tendered by the Rhine-Westphalian Section of the Verein deutscher Ingenieure

Tuesday, July 1

9.00 a. m. Excursions

Group 19: Haniel & Lueg, Düsseldorf-Grafenberg (50 participants)

Group 20: Ernst Schiess Company, Düsseldorf (50 participants)

Group 21: German Machine Works Company, Benrath plant, Benrath (50 participants)

Group 22: Steel Works of Becker Company, Willich b./Krefeld (75 participants)

Group 23: Trip into the mountains; inspection of the Elberfeld Lift railway, Barmer mountain railway, steel plant of Rich. Lindeberg Company, Remscheid-Hasten and the Mungsten Bridge

Group 24: The ladies will inspect some installations in the city of Düsseldorf

4.30 p. m. Departure for Cologne. Members of Group 23 go from Remscheid direct to Cologne

COLOGNE

Tuesday, July 1

5.30 p. m. Arrival in Cologne

8.00 p. m. Informal gathering in the Zoological Garden of Cologne tendered by the Rhine-Westfalen Board. Trip on the Rhine with illumination of the city and cathedral

Wednesday, July 2

9.00 a. m. Excursions

- Group 25: Dye Works, formerly Friedr. Bayer & Co., Leverkusen (up to 100 participants)
- Group 26: Gas Engine Works, Deutz, Cologne-Deutz (up to 100 participants)
- Group 27: Machine Works Humboldt, Cologne-Kalk (up to 100 participants)
- Group 28: The ladies inspect the cathedral and city

8.00 p. m. Reception in Gurzenich tendered by the city of Cologne

Thursday, July 3

8.00 a. m. Departure by rail for Coblenz; thence on the Rhine by steamer to Rüdesheim, where there will be a festival on the banks, and thence by rail to Frankfort-on-Main

FRANKFORT-ON-MAIN

Thursday, July 3

6.00 p. m. Arrival in Frankfort-on-Main

8.00 p. m. Reception in the Palm Garden by the Frankfort Section of the Verein deutscher Ingenieure

Friday, July 4

11.30 a. m. Welcome by the city in Roemer. Luncheon

2.30 p. m. Excursions

- Group 29: Eastern port and gas works
- Group 30: Stockyards and gasholders
- Group 31: Refuse destroyer plant and filters
- Group 32: Inspection of the old city, Goethe house, Historical Museum
- Group 33: Visit to Saalburg

7.30 p. m. Independence Day celebration with the American colony

Saturday, July 5

10.30 a. m. Departure for Mannheim

MANNHEIM

Saturday, July 5

12.00 m. Arrival; lunch in the Friedrichspark

Excursions

- Group 34: Machine Works, Heinrich Lanz
- Group 35: Machine Works, Sulzer Bros. in Ludwigshafen
- Group 36: Brown-Boveri & Co., electric machinery

Group 37: Cement Works in Leinen and their welfare activities
Group 38: Benz & Co. Rhine Automobile and Motor Works Company
Group 39: Inspection of the port (steam flour mills in Ludwigshafen)

8.00 p. m. Reception of welcome

Sunday, July 6

11.00 a. m. Departure for Heidelberg

HEIDELBERG

Sunday, July 6

12.00 m. Arrival; lunch in the Stadtgarten, inspection of the Castle, concert in the Castle Restaurant
6.00 p. m. Dinner on the Molkenkur tendered by the Board of Reception
10.00 p. m. Trip to the Castle, illuminated by fireworks,. Given by the City of Heidelberg
11.00 p. m. Return to Mannheim

MANNHEIM

Monday, July 7

10.00 a. m. Departure for Munich

MUNICH

Monday, July 7

5.00 p. m. Arrival in Munich
8.00 p. m. Reception of welcome in the Hofbrauhaus

Tuesday, July 8

9.30 a. m. Inspection of the German Museum and its new building
3.00 p. m. Trip to the Sternberger See
8.00 p. m. Concluding exercises in the Rathhaus

STUDENT ACTIVITIES

Much splendid work is being done by the student sections of the Society, which cannot fail to develop a general interest in engineering affairs and attract interest in the opportunities afforded by The American Society of Mechanical Engineers for engineering service. As reported in the usual place in The Journal, two of the student branches have held exhibitions of engineering appliances which have involved a great deal of work in their preparation and which reflect much credit upon the students through the good judgment displayed in the selection of apparatus.

One of these exhibitions was held at the University of Wisconsin, Madison. Certain of the agricultural students coöperated

with the members of the student section, and the exhibition was given at the new stock pavilion of the agricultural department, which has a stadium with an arena 170 by 70 feet. Floor space was sold to the dealers, the money received being used to cover the necessary expenses. The exhibition was advertised and brought prominently before the people of the state, the idea being that many people were ignorant of the application and operation of internal-combustion engines and that a show of this type of engine would be of real educational value. The exhibits included tractors, automobiles, farm engines and general utility gas engines, and motor boats.

The second exhibit mentioned was held at New Haven at the Mason Laboratory of Mechanical Engineering, and was arranged by the student branches of the different societies in the engineering department of the Sheffield Scientific School. It consisted of the regular apparatus of the laboratory, so arranged as to be demonstrated for the benefit of the visitors, supplemented by contributions from some twenty manufacturing firms. There were in all 85 different exhibits and student operators were present to demonstrate the working of the apparatus and explain its uses to those interested. The exhibit was so successful that between 2500 and 3000 attended during the three evenings when the apparatus was displayed.

Another event of interest was the annual meeting of the student branch of the University of Kansas at Lawrence. This is the fourth annual meeting to be held, and started with a session in the morning at which an opening address and professional papers were given. In the afternoon, there was a second professional session, and the affair closed in the evening with a banquet.

The reports which have come to the Society from the various student branches throughout the winter season have shown that many meetings have been held in the different colleges which were of real engineering value, the students often being addressed by prominent speakers. Such meetings must demonstrate to young engineers the desirability of getting together, and lead in after life to an association with others in their own and related lines of activity which is always beneficial.

A student branch has recently been formed at the University of Iowa, making twenty-eight in all now connected with the Society.

CURRENT AFFAIRS OF THE SOCIETY

Among the many bequests contained in the will of John Fritz, Honorary Member and Past-President, who died on February 13, 1913, the first to be mentioned were gifts to the Society. One of these, a fine mahogany hall clock, standing nearly eight feet high and valued at fifteen hundred dollars, has been placed in the rooms of the Society. It was presented to Mr. and Mrs. Fritz by their numerous friends on the occasion of Mr. Fritz's seventieth birthday, and bears the inscription, "Oh! Time deal gently with our loving friends, John and Ellen M. Fritz, August 21st, 1892, Bethlehem, Pa." Another and equally valuable bequest is the handsome silver loving cup presented to Mr. Fritz by Irving M. Scott, builder of the U. S. battleship *Oregon*, in recognition of the high quality of the product furnished by Mr. Fritz for the vessel. The cup, which is now in the Society's possession, is essentially artistic in the simplicity of its design and bears a map of the famous run made by the battleship in 1898 from Puget Sound to Key West, a distance of 14,712 miles, in less than two months. Upon it are inscribed the words, "To John Fritz on his Eightieth Birthday. The Builder of the West greets the Genius of the East. The Oregon's performance glorifies the steel of Fritz."

In addition to these gifts, the executors of the Fritz estate have placed in the custody of this Society his certificates of Honorary Membership in the technical and learned societies of the world, greetings from organizations, etc., and several medals which Mr. Fritz received. Among these the most precious are the original bronze medals presented by the John Fritz Medal Committee, together with the album of autographs of the 750 donors of the fund which established this medal; also the Bessemer gold medal and the Elliott Cresson gold medal. The portraits have also been received of W. R. Jones, Alex. L. Holley, and the much-prized autographed group of Mr. Fritz, Ambrose Swasey and S. T. Wellman. All these mementos will be preserved by the Society, and should serve as an inspiration to young men for earnestness of purpose and lofty ideals.

LICENSING ENGINEERS

The Conference Committee of the National Engineering Societies held a meeting during the month, to which were invited also representatives of the National Electric Light Association, the American Gas Institute, and the Institute of Consulting En-

gineers, to consider the propriety of preparing a bill for registering engineers, which should be offered to the Legislature of New York and other States should these bodies consider legislation in this matter essential. It was the sense of the conference that such a bill be prepared, and this recommendation has been made to the councils of the respective organizations represented.

UNITED ENGINEERING SOCIETY

At a recent meeting of the Board of Trustees of the United Engineering Society, the wish of the trustees that each governing body of the Founder Societies shall be completely informed both of the policies and of action taken at its meetings was expressed by a vote, inviting any officer or member of the governing body of a Founder Society to be present at any meetings of the Board, except such as may upon request of a member, supported by a majority vote of the Board, be conducted in executive session.

Calvin W. Rice, *Secretary*

NEW YORK MEETING, APRIL 8

In this issue is published a collection of thirteen papers upon the subject of Steel Car Design, given at the New York meeting of the Society on April 8. This meeting was one of the most largely attended monthly meetings ever held, and the interest in the subject was evidenced by the presence of many engineers and railroad men from outside the city. It further demonstrated the success which is being attained by the sub-committees appointed by the Committee on Meetings to arrange for the presentation of papers by the foremost authorities in different fields of activity. The papers for this meeting were secured through the solicitation of the sub-committee on Railroads, E. B. Katte, Chairman. At the invitation of the New York Local Committee, which coöperated with the Railroad Committee, the session was held at the time for the regular monthly meeting in New York.

It will be noted that the papers were all brief, each one treating of one definite subject upon which the writer is a specialist. This method of presentation of a subject is to be contrasted with the older and more familiar use of long papers, written by a single author and covering the whole field. While each method may have its advantages, it cannot be doubted that the former plan is more efficacious in arousing a general interest in the subject. Each man in turn presents his one point in a way

to direct the attention of the audience through his personality, making sure the sustaining of interest, as was the case at this meeting.

Following the presentation of the papers was a brief discussion by George Gibbs, John A. Pilcher, Wm. F. Kiesel, Jr., and S. A. Bullock. It is expected that some additional contributions will be received and publication of the discussion is therefore deferred until a later issue.

DINNER IN HONOR OF PROFESSOR HOLLIS

On Tuesday evening, April 29, a dinner was given at the Boston City Club by members of the Boston Society of Civil Engineers, the American Institute of Electrical Engineers, and of this Society, in honor of the appointment of Prof. Ira N. Hollis of Harvard University to the presidency of Worcester Polytechnic Institute. Dr. Richard C. MacLaurin, President of Massachusetts Institute of Technology, Dr. A. Lawrence Lowell, President of Harvard University, and other distinguished educators were present.

At the conclusion of the dinner papers illustrated by lantern slides were presented, one upon Some Phases of the Development of the Grand Central Terminal by George W. Kittredge, chief engineer of the New York Central lines, and another on Problems in Local Transportation, by Matthew C. Brush, second vice-president of the Boston Elevated Railway Company.

DEATH OF HONORARY MEMBERS

During the past few months, the Society has lost by death a number of its Honorary Members. An account of the career of two of these, John Fritz and Sir William Arrol, appeared in the April issue, and biographies of Carl Gustaf Patrik de Laval and Victor Dwelshauvers-Dery are given herewith.

CARL GUSTAF PATRIK DE LAVAL

On February 3 of this year there passed away an engineer of world-wide fame, Dr. Carl Gustaf Patrik de Laval, whom we are proud to have numbered among our honorary members. He was in his sixty-eighth year, in the full possession of those faculties, the conscientious use of which in the service of mankind had placed him in the front rank of his profession.

Dr. de Laval was born at Blosenberg in the Province of Dalecarlia, Sweden, on May 8, 1845, of a family of soldiers whose French ancestor rode to fame with Gustavus Adolphus. The inherited qualities of courage, alertness, endurance, and close observation, he carried into that nobler warfare with stubborn materials and elemental forces in which the wit of man conquers not by destruction but by making their energies his willing instruments.

In his eighteenth year he entered the technical department of the University of Upsala, and was graduated with distinction three years later, carrying with him, indeed, the highest honors in every department. His first position was with the Stora Kopparberg Company of Bergslad as a draftsman, but considerations of health forced him to give up this confining occupation for one with more opportunities for outdoor exercise. He accordingly decided to return to Upsala for further study, and in 1872 received the degree of Doctor of Philosophy. In the same year he re-entered the employ of the copper company and made for them investigations in the manufacture of sulphuric acid. Upon completion of this task Dr. de Laval resigned his position for a ven-

ture of his own, a glass factory at Falun, which, however, unfortunately failed, leaving him heavily in debt.

He then entered the employ of the Klosterverken Iron Works as engineer, and it was during his connection with this company and while carrying on his daily duties in the works that he developed from a crude German device the centrifugal cream separator which has made his name a household word on the dairy farms of the world. So absorbed did he finally become in its perfection that he gave up his position in order to devote his entire time to it. When it finally worked to his complete satisfaction he endeavored to secure in Stockholm the financial assistance needed to place it on the market, but it was only by extreme persistence that he was able to obtain even a small loan. Its manufacture proved an immediate success and it was not long before the Separator Company, Limited, was on a secure financial basis.

The cream separator called, however, for some means to drive it at the high speed required, and Dr. de Laval attempted to apply to it the ancient principle of Hero of Alexandria, driving a reaction wheel by two steam jets normal to the direction of rotation. This in its turn brought the inventor face to face with troubles with transmission and shafts rotating at high speeds, which he attempted to overcome by using a special bearing, lubricated by the oil acted on by centrifugal force, together with a high-speed worm-drive transmission. For many years cream separators were made with direct steam drive, but their economic efficiency proved to be poor. At the end of the eighties de Laval was ready with the first steam turbine, embodying practically all the features which have since become familiar to every engineer, such as conversion of the energy of high-pressure steam into velocity by means of the de Laval nozzle, the use of a wheel running at a very high speed, and the flexible shaft running at a speed far exceeding the critical speed. The new prime mover, running at what was then considered a frightful speed of some 24,000 r.p.m., which had to be reduced to one-tenth of it for driving the separators, did not prove convenient for this purpose and became the basis of a separate industry.

Dr. de Laval was not the type of man to rest content with one success and to devote his time to the management of his existing concerns, even though that clearly appeared to be the easiest way to wealth. In looking for new things to which to turn his in-

ventive genius, de Laval started the manufacture of milking machines, and when this enterprise proved unsuccessful, devoted his time and fortune to discovering a new process for treating low-grade Swedish zinc ores. This venture, which gave some interesting scientific results, proved so disastrous to him financially, that in 1908, at a time when the Separator Company in which de Laval was originally one of the largest shareholders, was more prosperous than ever before, his affairs were in such a state that the company voted him a pension of 12,000 krones.

Large rewards came to him in wealth and honor, but, instead of hoarding his gains, he saw in them only the means and the incentive for further work for the benefit and advancement of mankind. In the ethical, no less than in the intellectual sense, he deserves the title of a great engineer. Dr. de Laval was a member of the Swedish House of Lords and during his lifetime received many foreign orders and distinctions.

E. D. M.

VICTOR DWELSHAUVERS-DERY

On March 15, Victor Auguste Ernest Dwelshauvers-Dery, professor emeritus of the University of Liège, died in Belgium, bringing to a close a long life of service in the field of engineering research and investigation. Professor Dwelshauvers-Dery was born at Dinant on April 25, 1836, and receiving his early education at home, entered at the age of seventeen a small college in Brussels in which he gave special attention to the study of higher and applied mathematics. In 1861 he was graduated from Liège University with the diploma of mechanical engineer and in the same year accepted from his alma mater the position of lecturer in mechanics. The university's recognition of his talents was soon justified by his rise to the chair of professor of mechanics, a position which he held for many years.

The important thing to which Professor Dwelshauvers-Dery immediately directed his attention was the establishment of an engineering laboratory where theory might be compared with practice. He established in the university courses of lectures covering in detail the theory and construction of the steam engine and the economics of steam raising, and his object in securing a laboratory was the investigation of certain discrepancies between steam engine theory and practice. He began his efforts toward this end as early as 1870, but it was not for ten years

that they were even partially successful, a grant being then allowed him for the purchase of a steam engine, which, however, he had to run at his own expense outside of the university premises. In 1893 the laboratory was finally established according to Professor Dwelshauvers-Dery's original plan, and he immediately began there his experiments with steam consumption and steam jacketing, gathering about him in this work many brilliant students. The effect of high compression on steam economy was one of the earliest matters to be investigated, for which Professor Dwelshauvers-Dery designed an experimental steam engine where he was able to vary at will the steam distribution, the governing and also the degree of compression. From these experiments he obtained his theories on steam compression which are widely known. His views on the phenomena due to steam jacketing under most varying conditions, one of his favorite subjects, were presented at a meeting of the Institution of Mechanical Engineers and are published in their proceedings for 1905.

In 1900 Professor Dwelshauvers-Dery was invited to become rector of the university and was obliged in undertaking these heavy duties to interrupt his work in the laboratory. Three years later he retired from public life, but his advice and collaboration were still given freely wherever asked and he contributed extensively to the Belgian and French technical press.

Professor Dwelshauvers-Dery was honored in 1888 by the award by the Institution of Civil Engineers of the Watt Medal and Telford Prize for his paper on the Steam Engine Governor, and in 1889 he shared with Donkin a prize for investigations on the thermal action of walls of a steam engine cylinder. That his teachings were widespread in their effect is evidenced by the fact that the establishment of the laboratory in University College, London, was due to the work which he had done at Liège. He was a corresponding member of the British Association, the Institut de France, the Société Industrielle de Mulhouse, and the Société d'Encouragement pour l'Industrie Nationale, a commander of the Leopold Order, and a knight of the Legion of Honor.

THE MYRIAWATT AS A UNIT OF ELECTRIC POWER

In June 1912 a paper by H. G. Stott and Haylett O'Neill was read at the annual convention of the American Institute of Electrical Engineers which proposed the use of "the myriawatt as a unit of power" in connection with steam and gas engine units, steam boilers, etc. The myriawatt is equivalent to 10,000 watts and very nearly parallels the commonly accepted term boiler horsepower, being 2 per cent larger than this unit. Following the presentation of the paper upon the myriawatt the Council of The American Society of Mechanical Engineers appointed a committee to meet with the Standards Committee of the American Institute of Electrical Engineers and to report upon the subject of the myriawatt and its use in place of the older term of boiler horsepower. In The Journal for February 1913 the committee reported in favor of the myriawatt, and the original paper explaining its use was reprinted. The subject is now open for discussion and two contributions follow.

DISCUSSION

William Kent. The units of electric power in common use are the watt and the kilowatt (or 1000 watts). We do not use the dekawatt or the hectowatt (10 or 100 watts). Why should we use the myriawatt (10,000 watts)?

There is a general tendency to discontinue the use of unnecessary units; thus in English measures we have in common use the inch, the foot, and the mile, and in engineering we do not use the yard (except the cubic yard), the rod, the furlong or the league. We use the pound and the ton, and have abandoned hundred weights and quarters. In metric measures the kilometer, the meter and the millimeter, the gram, the kilogram and the milligram are commonly used, while the hectometer, the dekameter and the decimeter, the hectogram, the dekagram and the decigram are rarely seen. The gallon, a useless unit, is slowly being replaced by the cubic foot, and the grain, another useless unit, is being replaced by a decimal fraction of a pound. There

are two reasons for the tendency to discontinue the use of certain units: *a* because the average man cannot think in a great variety of units, and *b* because the use of fewer units tends to economize time in calculations. If electrical engineers wish to discontinue the use of the term horsepower, and to use the kilowatt as the unit of both electrical and mechanical power, it is because they think in kilowatts and wish to avoid the trouble of converting kilowatts into horsepower and vice versa. There is no objection to their doing this if they see fit, but there seems to be no good reason why they should use the myriawatt instead of the kilowatt. The mechanical engineer, however, thinks in horsepower. He finds the term in all his reference books and other engineering literature, and he will not take the trouble to express quantities of mechanical power in either kilowatts or in myriawatts if he can possibly avoid it.

It is suggested that the myriawatt be used for the input and the kilowatt for the output in computations of efficiency. To do this would be to violate the usual custom, which is to define efficiency ratio as the quotient of output divided by input, both numerator and denominator being expressed in the same unit, and to multiply this ratio by 100 or shift the decimal point two places to the right, to obtain the efficiency as a percentage. According to the suggestion of Messrs. Stott and O'Neill, the quotient of output in kilowatts divided by input in myriawatts has to be divided by 10 to obtain the efficiency ratio or multipled by 10 to obtain the percentage.

The chief objection the mechanical engineer will have to using the kilowatt or its multiple, the myriawatt, as a unit of mechanical power instead of horsepower is that the horsepower is directly derived from the two fundamental units, the foot and the pound (1 h.p. = 550 ft-lb. per sec., 33,000 ft-lb. per min., or 1,980,000 ft-lb. per hr.); while the kilowatt is 1000 times the product of volts, amperes and power-factor, no one of these being related to the foot or the pound, but requiring to be measured by indicating instruments, such as the voltmeter, ammeter, and wattmeter. Of course we can obtain the kilowatt from the mechanical units by using the conversion factor 1 kw. = 737.56 ft-lb. per sec., 44,254 ft-lb. per min., or 2,655,200 ft-lb. per hr., but who wishes to use such conversion factors when he can use the ones which he easily remembers, connecting the horsepower and the foot-pound. There might be a better mechanical unit of power

than the horsepower, say a "kilovim," 1000 ft-lb. per sec., 60,000 ft-lb. per min., or 3,600,000 ft-lb. per hr., but the old unit is so entrenched in custom and in literature that it cannot be done away with. The horsepower is here to stay and we can no more eliminate it than we can eliminate the gallon, whose only excuse for existing is that it is established by custom. The gallon is 231 cu. in. in the United States, and 277.274 cu. in. in England and in Canada, but bad as they both are, we cannot get rid of them.

There are three different kinds of units used by engineers in measuring quantities of energy or of power (rate of transmission or conversion of energy), namely, mechanical, electrical, and heat units. Mechanical energy is measured in foot-pounds, using a 2-ft. rule and a platform scale; mechanical power in foot-pounds per second or in horsepowers. Electrical power is measured in volt-amperes or in kilowatts by means of electric meters, and electrical energy is measured as the product of these units into units of time, such as seconds or hours. Heat energy is measured in British thermal units, and is the product of weight in pounds, specific heat and difference of temperature. Mechanical energy may be transmitted by a shaft or belt, and may be stored in a revolving flywheel, or, as potential energy, in a weight raised to a height above the earth, or in a compressed spring. Electric energy is transmitted as an electric current on a wire, and is stored in a storage battery. Heat energy is transmitted by radiation, conversion or conduction, and is stored in a mass of material raised to a high temperature. These three kinds of energy naturally are and should be measured in different kinds of units. Since the three kinds of energy can be converted one into another and the equivalent of one in terms of the other is known with considerable accuracy, the units may also be converted into one another by the use of certain numerical factors of conversion. Thus kilowatts may be converted into foot-pounds per second or into heat units per second; but there is no more reason why we should express the power transmitted through a shaft in kilowatts than why we should express it in heat units. When heat energy is converted into mechanical energy, and that into electric energy, we need the three kinds of units to express the amount of energy in each of its three forms, if we wish to convey to others a clear idea of the quantity of energy that is measured in each form, and to show the several losses, such as heat lost in the chimney, steam lost by cylinder condensation and discharged into the con-

denser, friction of engine, friction, windage and electrical losses in the generator. It may be convenient in some cases to tabulate all the losses, from the coal to the switchboard, in heat units, and to convert each expression of energy, measured in whatever form, into heat units, so as to make a heat balance, but there seems to be no occasion ever to record any of the quantities between the coal and the generator in kilowatts.

The following conversion table is practically all that is needed in computations of the different kinds of power and energy:

Kind of Unit		
Mechanical	1 h.p.	=0.7457 kw. =2546.5 B.t.u. per hr. =550 ft-lb. per sec.
Electrical	1 kw.	=1.3410 h.p. =3415.0 B.t.u. per hr. =737.56 ft-lb. per sec.
Heat	1 B.t.u.	=1/180 of heat of 1 lb. water between 32 deg. and 212 deg. fahr. =777.54 ft-lb.
	1 unit of evaporation	=970.4 B.t.u.

Messrs. Stott and O'Neill's chief reason for introducing the term myriawatt seems to be that they wish to substitute it for the boiler horsepower as a measure both of performance or capacity, and of rating for commercial purposes. Let us consider what the boiler horsepower is. It is not a measure of energy, either mechanical, electrical or thermal; it is merely a commercial term, applied to stationary boilers only, never to locomotive or marine boilers. It has two meanings: (*a*) a measure of the size of the boiler, that is, the extent of heating surface, it being customary to call 10 sq. ft. of heating surface a horsepower; (*b*) a measure of performance, merely the quotient of the equivalent pounds of water evaporated from and at 212 deg. per hr. divided by the arbitrary figure 34.5. The term originated many years ago in England, when very low pressures were used. It was customary to say that a boiler required to have 1 sq. yard of heating surface, 1 sq. ft. of grate surface, and to evaporate 1 cu. ft. of water, to develop 1 h.p. in a steam engine. The origin in this country of a more modern definition was probably due to Prof. R. H. Thurston, in connection with the steam boiler trials in the American Institute Fair in 1871. Steam pressures at that date averaged about 70 lb. gage, feedwater temperatures were variable, averaging about 100 deg., and the average engine was assumed to require about 30 lb. of steam per hour per horsepower. These figures were then combined in the definition of the horsepower of a boiler, not as a measure of power it could actually produce

in connection with any given engine, but merely as a unit for comparing one boiler with another. After that date it became customary to regard 15 sq. ft. of heating surface per h.p. the measure of size or rating of a boiler, but in later years competition among boiler makers brought the figure down to 12 sq. ft. and finally to 10 or less. The judges of the boiler trials at the Centennial Exhibition in 1876 used in their report the same definition of the boiler horsepower, 30 lb. per hour from feed at 100 deg. into steam at 70 lb. gage pressure, and the first committee of The American Society of Mechanical Engineers on boiler trials in 1884 reaffirmed it, but added to it these words: "which shall be considered to be equal to 34½ units of evaporation, that is, say, to 34½ lb. of water evaporated from a feedwater temperature of 212 deg. fahr. into steam at the same temperature. This standard is equivalent to 33,305 thermal units per hour." The committee of 1899 also readopted the 34½ lb. standard, but as the definitions of the heat unit and of the unit of evaporation have since been slightly modified, the heat equivalent of the boiler horsepower became $34\frac{1}{2} \times 970.4 = 33{,}479$ thermal units per hour.

The present Committee on Power Tests of the Society in its preliminary report,[1] recognizing the validity of the objections to the boiler horsepower in these days of high-pressure steam and of steam turbines, abandoned it as a standard unit of boiler capacity, and adopted as the standard unit "1 lb. of water evaporated into dry steam from and at 212 deg. per hour," and put in a foot-note the statement "a subsidiary unit which may be used for stationary boilers is a 'boiler horsepower,' or 34½ lb. of water evaporated from and at 212 deg. per hour, i.e. from water at 212 deg. into steam at the same temperature."

Messrs. Stott and O'Neill have taken up this old and discredited unit, which never was a scientific unit but only a commercial one, modified it about 2 per cent, so that it is no longer 34½ lb. but 35.192 lb., equivalent to 34,150 B.t.u. per hour, and instead of giving it a name which will show that it has some relation to a steam boiler, they call it a myriawatt, which is nothing more nor less than 10 kw., an electrical unit, neither a unit of thermal capacity nor of mechanical power. They go still further and ask us to adopt this myriawatt as a unit for turbines, waterwheels, gas engines, and gas producers, for all of which the boiler horse-

[1] The Journal, November 1912, p. 1706.

power was never designed and never used. They ask us to measure input in myriawatts and the output in kilowatts, and to change the meaning of efficiency, so that it is no longer output divided by input in the same units, but output in kilowatts divided by input in myriawatts, and this quotient divided by 10 to get the efficiency ratio, or multiplied by 10 to get the efficiency percentage.

In former times when computing a boiler test, we found the equivalent evaporation in pounds per hour and divided it by 34.5 to obtain the boiler horsepower; now we must divide by 35.192, or multiply by 970.4 and then divide by 34,150 to get the myriawatts. In former times when computing the test of a waterwheel, we obtained the foot-pounds of work done per minute by a Prony brake and compared it with the foot-pounds of potential energy of the water, dividing the former by the latter gave the efficiency, or dividing each by 33,000 gave the horsepower, developed and potential. Now we must convert the foot-pounds per minute into myriawatts, and we need a new conversion table for the relation of myriawatts to other kinds of units, such as is given in Messrs. Stott and O'Neill's paper. The following is an example showing the calculations required in connection with the test of a steam-electric plant in order to obtain the several efficiencies. The old method and the proposed method are shown in parallel columns. A careful examination of the calculations given in the last column will show that the myriawatt method has no advantage whatever over the old method, but on the contrary it is more inconvenient and troublesome:

	B.t.u. Method	Myriawatt Method
Coal, lb. per hr.	1000	
Coal, B.t.u. per lb.	14000	$\div 34150 = 0.40996$ mw.
Steam, lb. per hr.	9000	
Feedwater temperature, deg. fahr.	110	
Steam pressure gage, lb.	150	
Factor of evaporation	1.151	
Equivalent evaporation, lb. per hr.	10,359	
Equivalent evaporation per sq. ft., heating surface per hour	3.45	
Equivalent evaporation per lb. coal	10.36	
Boiler horsepower, 10,359÷34.5	300	$\frac{10359 \times 970.4}{34.50} = 294.1$ mw.
Pipe leakage and radiation, 2 per cent, lb.	180	
Steam to engine, lb.	8820	

Heat per lb. steam from 110 deg. fahr. to 150 lb., B.t.u.	1117	÷34150 = 0.032709 mw-hr.
I.h.p. of engine	600	×0.07457 = 44.742 mw.
Kw. at switchboard	380	380 kw.
Steam per i. h.p. per hr., lb.	14.70	×13.41 197,13 lb. per mw-hr. (engine)
Steam per kw-hr., lb.	$\frac{8820}{380} = 23.21$	23.21 lb. per kw-hr. (switch-board)

Per Cent Efficiency

$\frac{\text{kw.}}{\text{1 h.p.}}$	$\frac{380 \times 1.341}{600} = 84.93$	$\frac{380 \times 10}{447.42} = 84.93$
$\frac{\text{kw.}}{\text{steam}}$	$\frac{380 \times 3415}{8820 \times 1117} = 13.17$	$\frac{380 \times 10}{8820 \times 0.032709} = 13.17$
$\frac{\text{1 h.p.}}{\text{steam}}$	$\frac{600 \times 2546.5}{8820 \times 1117} = 15.51$	$\frac{44.742}{8820 \times 0.032709} = 15.51$
$\frac{\text{Steam to engine}}{\text{coal}}$	$\frac{8820 \times 1117}{1000 \times 14000} = 70.37$	$\frac{8820 \times 0.032709}{1000 \times 0.40996} = 70.37$
Boiler and furnace	$\frac{10359 \times 970.4}{1000 \times 14000} = 71.80$	$\frac{10359 \times 970.4 \div 34150}{1000 \times 0.40996} = 71.80$
$\frac{\text{kw.}}{\text{coal}}$	$\frac{380 \times 3415}{1000 \times 14000} = 9.27$	$\frac{380 \times 10}{1000 \times 0.40996} = 9.27$

The authors of the paper will not succeed in persuading the mechanical engineering profession to adopt the myriawatt, but they can introduce it into literature, to the confusion of engineering students of the future. Already the Electrical Review of Chicago[1] has editorially commended it, saying, "the suggestion is an admirable one and will appeal to every electrical engineer. The suggestion has been adopted by a joint committee of the American Institute of Electrical Engineers and The American Society of Mechanical Engineers, and this should guarantee its gradual introduction into general practice." The Review apparently delights in suggestions, for in the same editorial it says, "another suggestion has been to apply the name of 'kelvin' to a unit representing 10,000.000 joules, which will give a unit of commercial size. A joule represents 10,000,000 ergs. This unit would represent 2.78 kw-hr."

On the other hand the Electrical Review of London[2] makes fun in an editorial of the myriawatt. It says, "What we cannot understand, however, is why in the name of common sense they want to measure the input by a unit ten times that used for the

[1] February 1, 1913.

[2] January 31, 1913.

output. Have our cousins lost their traditional sense of humor?" It is evident that our English friends will not adopt the myriawatt, and if our writers and text books adopt it, we shall have another instance of the two English speaking nations using different technical terms and definitions.

It is easy to make suggestions for new units, and it is easy for an eloquent and forceful man to persuade a committee to adopt them. It is easy also for newspaper men, college professors and text-book writers to put them into literary use. But it is hard to do away with them. Many years ago some one invented the term "poundal" as a unit of force. It was accepted by practically every text-book writer on physics and mechanics. It was taught in the colleges to thousands of students, wasting their time and confusing their minds, but it was never adopted by any engineer in his practice, and only within the last five years have we seen signs that it is getting into disrepute among text-book writers. In 1876 an international committee of metallurgists forced upon the literary world a definition of steel which was not known in commerce, and invented the terms ingot iron, ingot steel, weld iron, weld steel, which immediately began to infest metallurgical literature. They remained in the papers and text books for many years, but commerce never adopted them, and they have now practically died out from literature. About 1890 the British Association for the Advancement of Science had a committee on standard units and they invented a whole list of new names, a velo, a celo, a bole, a kine, a barad, a dynam.[1] They were given prominence in the papers for a while, but they are now forgotten. The electrical engineers for many years had the weber, but modern text books have dropped it. New units may be suggested, may be reported on by committees, approved by editors, adopted in text books, and used to torture students, but it is hard to get them adopted in practice. Let us hope that the myriawatt will not persist in literature as long as the poundal and ingot iron and the weber did, but rather that it will "die a-bornin'" as did the velo and the celo and the dynam.

THE VIM SYSTEM OF ENERGY UNITS

Besides the paper by Messrs. Stott and O'Neill, there has been another recent attack on the English system of units of power and energy, viz., the attempt of the Bureau of Standards[2] to destroy

[1] See The Engineer (London), July 4, 1890.

[2] Circular No. 34, June 1912. The Relation of the Horsepower to the Kilowatt.

the old definition of a horsepower as 550 ft-lb. per sec., or 33,000 ft-lb. per min., and to define it as 746 watts.

Practically the only excuse for the introduction of these new definitions or units is that there is some little difficulty and liability of error in making the arithmetical computations required to translate horsepower into kilowatts, kilowatts into foot-pounds per second, etc. The difficulty arises from the fact that when the practical electric units, watt, ampere, etc., were originated, no attempt was made to connect them with any units of the English system, but instead they were connected with the C. G. S. system by the relation, 1 watt = 10,000,000 or 10^7 C.G.S. units, the unit of force in that system being the dyne, which has the most inconvenient relation to any practical unit, either of the English or the metric systems, viz., 1 dyne = 1/980.665 gram, the gram (force) being the force that gravity exerts on a gram of matter at a location where $g = 980.665$ centimeters (= 32.1740 feet) per sec.

Even if the mechanical and electrical units were brought into harmony, the fact remains that there is no simple relation between any other energy unit and a heat unit in either the English or the metric system; thus the mean calorie is defined as 4.1834×10^7 ergs.* and the B.t.u. is equivalent to 777.54 ft-lb., and the kilowatt to 3415 B.t.u. per hr.

If there are to be any changes made in our system of units, for the purpose of simplifying arithmetical work and lessening the number of factors of conversion that are needed, it is suggested that an attempt be made to bring both electrical and thermal units into a simple relation with the English system. The writer has discovered a method of doing this and wishes to submit it for discussion. He calls it the "Vim System" (from the Latin, *vis*, force, power, energy).

The vim system has the pound,[1] foot, second and volt as basal units, and two new basal units, the therm = 5/7 kilogram calorie = 9/7 B.t.u., and the vamp = 1.3558 amperes. From these six units are derived the following:

1 vim = 1 ft-lb. per sec. = 1 volt-vamp (direct-current) = 1.3558 watts

1 kilovim = 1000 ft-lb. per sec. = 1 therm

Equivalents of New and Old Units

1 kilovim = 1.3558 kw. = 100/55 h.p.

* Steam Tables and Diagrams, Marks and Davis, p. 92.

[1] Pound force, the force that gravity exerts on a pound of matter at any place where $g = 32.1740$.

1 h.p. = 550 ft-lb. per sec. = 0.55 kilovim = 0.55 therm = 745.7 watts *
1 therm = heat required to raise 1 lb. water 5/7 deg. cent. or 9/7 deg. fahr. = 9/7 mean B.t.u. = 1000 ft-lb. per sec. = 1 kilovim-second
1 unit of evaporation (970.4 mean B.t.u.) = 754.8 therm
1 vim-second = 1 volt-vamp = 1 ft-lb. = 1/1000 therm
1 B.t.u. = 777.54 ft-lb. = 7/9 therm = 0.77778 therm †
1 kw. = 0.73756 kilovim = 737.56 vim = 737.56 ft-lb. per sec. = 1.3410 h.p.
1 ampere = 0.73756 vamp

All that is needed to facilitate the introduction of the two new units, the therm and the vamp, is to make a new graduation on the thermometer scale, so that 1 deg. V = 5/7 deg. cent. or 9/7 deg. fahr. and a new graduation on the ampere-meter, so that 1 vamp = 1.3558 ampere. Since amperes = volts ÷ ohms, a new unit of resistance, the vohm = 0.73756 ohm, will be needed to make vamps = volts ÷ vohms.

If a new thermometer scale is adopted with the value of the degree taken at 10/14 deg. cent. = 9/7 deg. fahr., the question arises where shall the zero be located. The centigrade scale is defective in having its zero at the freezing point of water, making it necessary in so many cases to use minus figures. The fahrenheit zero is scarcely low enough. It would be well to place the zero of the new thermometer below the freezing point of mercury. If we place it at 60 deg. below the freezing point of water, we shall have 200 as the boiling point, and the relation between the new scale and the old ones will be expressed by the following formulae:

$$\text{Deg. V} = 1.4\ C + 60 = 7/9\ (F - 32) + 60$$

The zero of the new scale will be at −42 6/7 deg. cent. and −45 1/7 deg. fahr. The relation of the three scales is shown herewith:

Deg. Cent.	Deg. Fahr.	Deg. Vim	Deg. Cent.	Deg. Fahr.	Deg. Vim
−50	−58	−14	30	86	102
−40	−40	4	40	104	116
−30	−22	18	50	122	130
−20	− 4	32	60	140	144
−10	14	46	70	158	158
0	32	60	80	176	172
10	50	74	90	194	185
20	68	88	100	212	200

The merits of the proposed system are undeniable. Two ques-

* This value, 745.7, is correct if the value of g is taken at 32.1740.

† This relation makes 1 therm = 1000.3 ft-lb. If the equivalent of the B.t.u. is taken as 777.778 ft-lb. then 1 therm = 1000 ft-lb. exactly.

tions arise concerning it: (*a*) Do its demerits, if any, offset its merits? (*b*) Is it possible to have a new thermometric scale and a new ampere (the vamp) introduced into engineering practice, and to have people think in therms, kilovims and vamps?

George H. Barrus. It is hoped that the members of The American Society of Mechanical Engineers will not be induced to adopt the recommendations of the three electrical engineers constituting the Committee on Myriawatt, as reported in the resolutions published in the February Journal of the Society. By examining the preamble of the resolutions it will be seen that these recommendations are based solely upon the paper by Messrs. Stott and O'Neill and as no other justification for the committee's action is given, the paper itself may properly be analyzed with a view to determining the exact merits of the subject.

In the opening paragraph, the term myriawatt is launched upon engineering literature as "a new unit of power." The myriawatt is not a new unit. It is no more a new unit than the watt, and it is not even a unit, because the watt is the real unit, and its characteristic as a unit is in no wise changed simply by multiplying it by 10, 100, 1000, or 10,000. A myriawatt is not a whit more a new unit of power than a kilowatt (and it is not by any means so well adapted for such a unit as the kilowatt) because the prefix "myria" is rarely used and comparatively unknown, while the prefix "kilo" is at the end of almost everyone's tongue who has to deal with weights and measures.

In the same opening paragraph the paper next affirms that the proposed new unit "if adopted will afford a basis of comparison of all converters of energy, thermal or mechanical." What is the matter with the watt or the kilowatt affording just such a basis of comparison without the adoption of anything new? There is no particular virtue in using 10,000 watts as a basis of such measurement instead of 1000 watts, or even 1 watt. The watt is the basis of them all and that basis is available now and has been available heretofore for anyone who cares to employ an electrical unit for the comparison of different forms of energy.

The same paragraph goes on to assert that the proposed unit if adopted will be "international in its character." The watt unit is already international in character just as it has been for years past. Multiplying this unit by 10,000 introduces not one iota of change in its international characteristics.

Continuing the first paragraph, the paper then proclaims that the proposed unit is "merely a new multiple of the watt." What is there new about the figure 10,000? Or, for that matter, what is there new about any known multiple? Why all this juggling of electrical language when the whole matter avowedly simmers down to simply a "multiple of the watt," one of the commonest of electrical standards?

Let us now consider the reasons presented in the paper for adopting the proposed myriawatt basis of boiler capacity:

The first reason advanced is that "laborious calculations" are involved in the conversion of the various power units of different countries to the same basis of comparison. It is quite true that a certain amount of calculation is required to convert a result figured on one basis to that referred to another basis, but to affirm that the calculation is laborious or to give the impression that it involves a number of computations is wholly misleading. There is many an engineer who can make such a calculation in his head and determine the substantial result almost at a glance. It is merely a question of one simple multiplication and one simple division.

Second, in referring to the use of the expression boiler horsepower the authors make the facetious observation that "one has yet to find where the 'horse' comes in." The term myriawatt, however, is just as foreign to the work of a boiler as the appellation horse. The function of a steam boiler is solely to evaporate water and make steam. It does not fabricate watts any more than it breeds horses, and if it is wrong to express its output in terms of horsepower, it is equally wrong to express it in watt-power or in myriawatts.

As a third reason for the adoption of the myriawatt, the paper refers to the growing use of the term kilowatt which it characterizes as "the one unit of power output." Almost in the same paragraph the authors override this one and only kilowatt unit of power output and substitute the myriawatt, stating as the alleged object "to form a connection between the boiler...... and the generator......" In other words the kilowatt connection between the two, which is already available to those who care to make use of it, is raised tenfold, and then it becomes the one thing needed to bind the two together. Why the connection between a boiler and generator secured by using the multiplier 10 is any different from that secured without such a multiplica-

tion, is not explained, but it may be inferred from the stress which is later placed on the fact that 10,000 watts differs only 2 per cent from a boiler horsepower, that it is deemed advisable to cling as closely as possible to old associations, even to the old "horse," and then give him a kick and throw him over.

The paper states that the proposed myriawatt is designed to apply to the output of a boiler or producer, which corresponds also to the input of all dynamical machinery, and that the term "by its very sound gives a clue to its meaning." The spoken sound of the word "myriawatt" gives not the faintest idea whether the word refers to input or output of a boiler or producer, any more than it does with reference to input or output of the machinery which it supplies. It does not furnish even a clue by sound regarding the number of watts to which it refers such as would appeal to ordinary engineers and laymen. Very few engineers are educated in Greek derivatives, from one of which the term myria is selected. Engineers and laymen are familiar with the word "myriad," which is in common use; but this word ordinarily carries with it no idea of a fixed number like 10,000. Webster's dictionary gives for a first definition of the word myriad "a vast indefinite number," which is a further indication that the mere sound of the word myriawatt furnishes no clue to the meaning of the term, as alleged.

The paper submits an expression for efficiency percentage, based on the use of the proposed myriawatt, which is

$$\frac{\text{10 kw. output}}{\text{myriawatt input}}$$

This is merely another mode of expressing the relation

$$\frac{\text{quantity of output}}{\text{quantity of input}}$$

irrespective of the unit employed in expressing the two quantities. This efficiency fraction referred to myriawatts is readily changed by substitution to read

$$\frac{\text{10 kw. output}}{\text{10 kw. input}}$$

and the latter expression, after cancelling the two figures 10, becomes simply

$$\frac{\text{kw. output}}{\text{kw. input}}$$

Thus it appears that the myriawatt drops out and becomes the

kilowatt, and in so doing it leaves a much simpler fraction, and one unincumbered by an unknown or unrecognized term. This fact is made doubly clear by the following numerical example:

Assume an output, measured at the switchboard, of 1000 kw.; a steam consumption, all-told, of 20 lb. per kw-hr.; a steam pressure of 150 lb.; a feedwater temperature of 100 deg.; and a percentage of moisture in the steam amounting to 1 per cent. Using these data for the computation of efficiency, there are certain preliminary calculations required, the first of which is the determination of the heat units in the steam. The number of heat units per pound of steam corrected for moisture is found by working out the following calculation, the items given being taken from steam tables:

$$(1195 - 68) \times \left[1 - 0.01\left(\frac{1195 - 338}{1195 - 68}\right)\right]$$

The resulting B.t.u. becomes 1118, and the heat units consumed per hour, $1118 \times 20 \times 1000 = 22{,}360{,}000$ B.t.u. From this quantity the myriawatt input is obtained by dividing it by 34,150, or the B.t.u. corresponding to 1 myriawatt. This division gives 654.7 myriawatts. Inserting the required data in the formula, we now have

Efficiency percentage by myriawatt expression =

$$\frac{10 \times 1000}{654.7} = 15.2 \text{ per cent}$$

By the simplified expression above noted we have efficiency by kilowatt basis equals

$$\frac{1000}{6547} = 0.152$$

one of these results being expressed in percentage and the other in a decimal fraction.

The example above given reveals incidentally that the use of the myriawatt for the purpose noted is by no means the easy problem which appears on the face of the formula. To determine the number of myriawatts, there must first be found the heat consumption. There is no short cut for this calculation. All the elements illustrated in the example enter into the determination. Having then found the hourly number of heat units consumed, this quantity must be divided by the number representing 1 myriawatt, viz. 34,150, before the myriawatt input itself is determined.

As a further reason favoring the myriawatt, the paper asserts that its use saves the "tedious operation" involved in finding the heating surface of a boiler plant from the kilowatt output of the engine, when the engine efficiency is known. Instead of involving a tedious operation as alleged, one can apply the boiler horsepower unit and make the calculation in his head. It is only a matter of adding 2 per cent to the result obtained by the proposed myriawatt method; or, to express the exact process, multiplying the kilowatt output by the factor

$$\frac{1020}{\text{per cent efficiency}}$$

instead of the factor

$$\frac{1000}{\text{per cent efficiency}}$$

The minute difference in the element of tediousness involved in these two operations is microscopic indeed.

Coming to the question of applying their myriawatt to the efficiency of steam and gas power plants, the authors meet a veritable Waterloo. It is unequivocally stated that the myriawatt is the term expressing output of steam boiler or gas producer, yet when the power plant is considered as a whole, they set aside this application of the term, and change the myriawatt to mean the input of the boiler or producer as determined from the heat value of the fuel. Thus, strictly speaking, the application of the myriawatt to the plant as a whole makes the efficiency of the boiler or producer 100 per cent—for the input is the output! The absurdity of this situation needs no further comment.

After three times submitting the efficiency formula as applied to various classes of power development which reads

$$\text{percentage of efficiency} = \frac{10 \text{ kw. output}}{\text{myriawatt input}}$$

the authors sum up their conclusions by saying, "Thus, in the term myriawatt lies a simple, logical, and universal means of comparing outputs and inputs of all classes of energy converters." The myriawatt does not furnish a means of such comparison when referred to methods now in vogue, which is either simple, logical, or universal. It is not as simple a means of comparison as the accepted thermal method. Thermal efficiency is given by the expression

$$\frac{2546.7}{\text{B.t.u. per h.p-hr.}}$$

i.e., a constant quantity divided by a single variable, the variable being merely one of the quantities regularly determined on a test. The myriawatt method requires two variables, i.e., one variable quantity divided by another variable quantity, and one of these variables is a new quantity not otherwise computed and requiring an independent calculation.

Neither is the myriawatt method so simple as the use of a kilowatt basis, which has been fully pointed out.

The proposed method is not as logical as those now in vogue. There is nothing logical in adopting a new unit of measure when the existing unit answers the same purpose in a better manner. If the input and output require to be expressed by electrical units, the watt is the only logical unit; or if a multiple of the watt is desired, the logical multiple is the kilowatt which is universally known and perfectly adapted to the purpose, and not a trumped-up multiple which is recognized by no one and which is in no sense specially fitted for such use.

Even the watt, it must be admitted, is not a logical unit for the purpose. There is no characteristic pertaining to electrical work, which makes a watt, or any other electrical unit, a logical representative of the heat produced by the combustion of coal, or representative of the number of pounds of water evaporated in a boiler, or of the weight of steam passing into an engine cylinder or turbine, or of the number of cubic feet of gas or weight of fuel supplied to a gas or oil engine. Neither is there any logical connection between the electrical unit watt, or any other electrical unit, and the power developed on the shaft of a prime mover. Such a unit is absolutely foreign to the principal work required of locomotives, or that of steamship power plants, or of rolling mill engines, of blowing engines, of air compressors, of pumping engines, or of belt-driven manufacturing plants, and the like. It is true that some small part of the heat energy of an electric power plant is converted into electrical energy, and from the viewpoint of the electrical generator in such cases the watt seems on the surface to be the logical unit by which to trace the change of energy from furnace to switchboard. Even this, however, is a very short-sighted view of the matter for the reason that out of the total heat energy of the coal consumed barely one-eighth reaches the bus-bar in the form of watts. The inventors of the proposed myriawatt expression may be thanked for the example given on the closing page of their paper which calls

attention to this telling bit of information. The watt output of the steam power plant referred to in this example is 12 per cent of the input at the furnace. We certainly do not want the tail end of a few power plants to be given such a controlling influence over the vast aggregate of power plants in general. The broad field of mechanical engineering which has to do with measuring the various forms of energy with which it is so widely concerned, finds no place for a unit of comparison that is so narrow in its application as the unit watt.

The only absolutely logical method of expressing the various forms of energy with which power plant apparatus is concerned, is thus shown to be the use of some form of heat measurement. Even the paper itself vouches for the truth of this assertion. The British thermal unit is the only absolute standard which the paper countenances, and, what is more, the underlying principle concealed within the mystical and meaningless flourish of myriawatts in this paper is the advocacy of a heat unit standard of comparison.

These are all the reasons advanced in the paper in favor of the proposed myriawatt basis of measurement, and so far as I can see, not a single one justifies its adoption.

Turning now to the resolutions adopted by the joint committee reported in the February Journal, there is no call for the new term myriawatt as applied to boiler capacity or to any other measure of thermal or mechanical power as referred to in the first resolution, because the familiar term kilowatt is wholly adequate for the purpose, whenever any such electrical quantity is needed.

As regards the recommendation contained in the second resolve that the myriawatt expression of thermal or mechanical power be exclusively used "in connection with boilers, producers, turbines, and engines," it is almost preposterous. There is a familiar saying that it is one thing to lead a horse to water, but it is quite another thing to make the horse drink. Such a recommendation by its very nature is so drastic as to defeat its own object. Where is the mechanical engineer who will adopt the term myriawatt for expressing boiler input or output, engine or turbine power, and exclude the various familiar expressions relating to mechanical energy at the behest of this recommendation? Likewise how many steam users will be content to abandon the familiar term expressing the horsepower of a boiler and sub-

stitute myriawatts, just because a high-tension electric imagination views the boiler as a watt-maker instead of a steam-maker. Mechanical engineers have no use for myriawatts and it is sincerely hoped that the Special Committee of Electrical Engineers who are trying to induce the membership to adopt them in their power calculations will find their efforts have been in vain.

THE PROTECTION OF MAIN BELT DRIVES WITH FIRE RETARDANT PARTITIONS

WITH OBSERVATIONS ON THE SAFEGUARDING OF VERTICAL OPENINGS THROUGH FLOORS AND THE RELATION OF SUCH PROTECTION TO THE SAFETY OF OPERATIVES EMPLOYED IN MANUFACTURING ESTABLISHMENTS

By C. H. Smith

ABSTRACT OF PAPER

In manufacturing establishments approved forms of construction and complete fire protection have proved their value not only in reducing property losses by fire, but in promoting the safety of the operatives employed as well. The importance of safeguarding the vertical openings through floors at stairs and elevators by placing them in towers well cut off from the remainder of the building has long been recognized.

The need of adopting similar safeguards at belt or rope drives was less fully appreciated, and the introduction of such protection was handicapped by the lack of a construction suitable for use in mill buildings where the belt or rope towers were not provided for in the original design. Partitions of expanded metal and cement construction 2 in. or more in thickness have been found well adapted for the enclosure of such main drives in existing buildings. Such fire retardant partitions are also adaptable for the enclosure of stairways and elevators where the hazards are not too great and where walls of brick or of concrete cannot well be employed. Also for the segregation of special hazards, the construction of bins for inflammable stock, the separation of lacquer rooms, and the like. These cement partitions can be installed at a cost not greatly in excess of the combustible forms of construction usually employed.

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By C. H. Smith,[1] Boston, Mass.

Non-Member

The importance of safeguarding stairways by placing them in towers well cut off from the remainder of the building and of protecting the openings made by elevators through the floors has long been recognized. Today more than formerly, these features are taken care of in the design of manufacturing buildings, including also well arranged towers for the main belts or ropes where this method of driving is employed. Fig. 1 shows how these features may be taken care of in a textile mill.

2 The following remarks apply more particularly to the older manufacturing buildings and to those of more recent construction where the best principles of design of stair and elevator towers and belt and ropeways have not been followed. Neglect to safeguard vertical openings through floors has resulted in serious loss of life among occupants of the building, who found themselves cut off from their accustomed exits by the rapid spread of fire up through such unprotected openings.

3 In mills insured with the Mutual companies stairs and elevators have generally been well arranged, and the fire protective devices such as automatic sprinkler systems, etc., have shown their value not only in reducing the loss of property by fire to a minimum, but also it has been demonstrated that approved construction, high standards of general order and neatness and efficient fire protection works as well to safeguard the lives of operatives employed.

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

4 At the present time there are approximately 1,500,000 people employed in the 2800 industrial works insured with the Mutual companies, located in 29 states of the Union and Canada. Since the inception of the system in 1835, there have been but 32 deaths caused directly by fires in these properties and 21 were in a fire in an unsprinklered mill in 1876 before sprinklers were in general use. This would indicate that under present conditions, the loss of life would average less than 1 per year per 1,000,000.

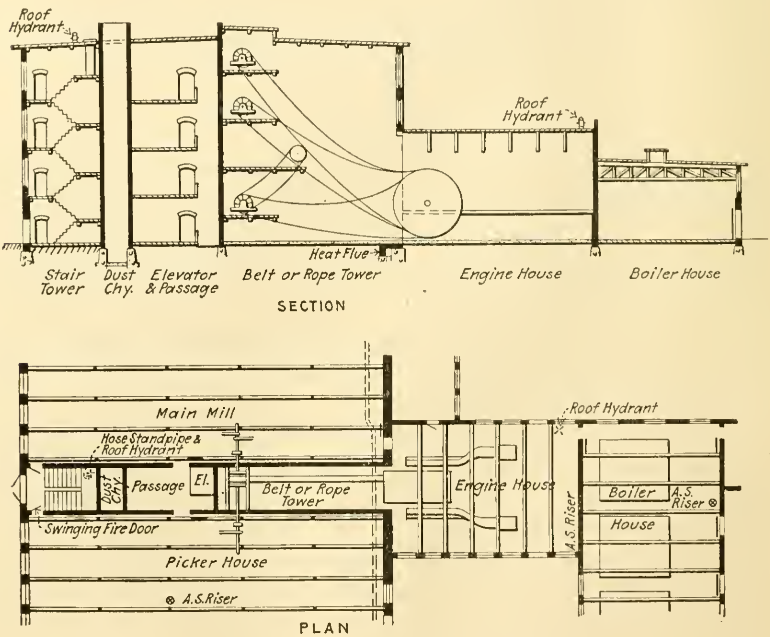

FIG. 1 BELT, STAIRWAY AND ELEVATOR TOWERS

5 Of the total of 32 lives lost, poorly constructed beltways which allowed the rapid spread of smoke and flame were to a large extent responsible for the deaths of 25 persons. The need of safeguarding the vertical openings through floors around the main driving belts had been less fully appreciated. Conditions at these drives were aggravated moreover, because it was the general custom to enclose the belts with boxes of wood, which in some cases were about head high and in others extended to the ceiling. The boxes tended to become oil soaked and to ac-

cumulate lint. A fire once starting at or near them would rapidly make headway, being carried by the natural draft up through the mill. Such a fire would also be more or less sheltered from the action of the sprinklers in the room.

6 The recurrence of several large property losses from this source led to consideration of this matter and measures were taken which have to a great extent eliminated the open beltway hazard from Mutual risks. In the experience of these companies there have been about 20 fires occurring in the vicinity of main

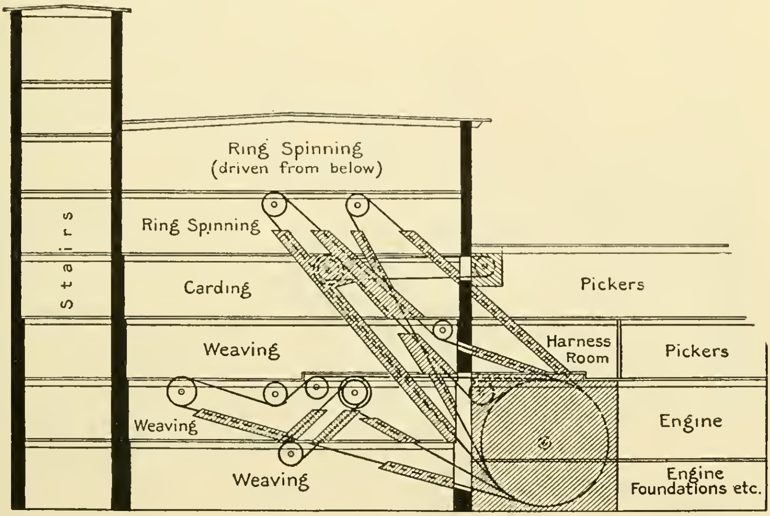

FIG. 2 SECTION SHOWING BELTS AND WOODEN BOXING BEFORE FIRE OF SEPTEMBER 15, 1907

drives in which the open beltway was an important factor in the spread of the fire. These 20 fires resulted in a total loss of \$2,721,635, an average of \$136,082 per fire. Some of the larger of these losses occurred in the days before sprinkler protection was as complete as now, but the statistics showed that even with complete protection the open beltway was a serious hazard.

7 The last bad fire from this source occurred September 15, 1907, at a cotton manufacturing establishment in Fall River. This is a stone mill, 339 ft. long, 74 ft. wide and five stories and basement in height with a 4-story wing, 94 ft. long and 65 ft. wide, projecting from the rear at the center of the mill. The engine room was located in the first story of this wing. The

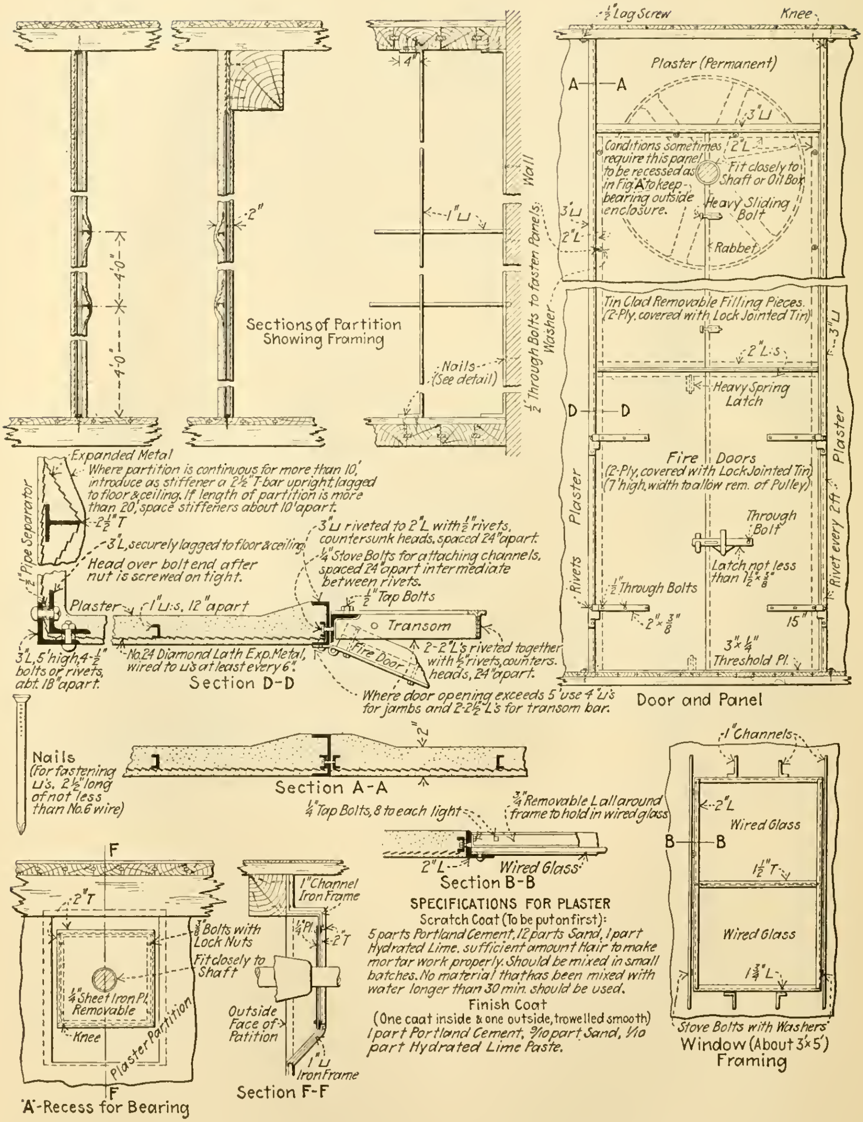

FIG. 3 DETAILS OF CONSTRUCTION FOR FIRE RETARDANT BELT ENCLOSURES

belts were boxed with wood and most of these were cut off head high in the several stories. Fig. 2 shows the general arrangement of the drive.

8 Sunday forenoon a bearing in the beltway just above the flywheel was being repaired. While the man doing the work stated that he had no knowledge of anything that could cause the fire, it is probable that its origin was connected with his work. After completing the job he left the locality. On returning 10 minutes later, he saw fire just below where he had been at work, and gave the alarm.

9 The fire passed up through the wooden belt boxing into all stories as far as the fourth floor where the drive terminated. The mill filled with heat and smoke so rapidly that in 5 minutes no one could enter the rooms. This was in spite of 650 sprinklers which opened, but in justice to the sprinkler equipment, it should be stated that the water pressure at this mill was weak. A section about 50 ft. wide was badly burned on each side of the main drive up through the mill.

10 After this fire plans were worked out to enclose the main drives with partitions of a fire retardant character, so as to approximate the standard belt tower with brick walls, such as are found in many mills of modern design.

11 The limitations of cost, available space, etc., which prevail in many places where the belt tower is not a part of the original design, make necessary special construction such as was adopted in this case, and has been successfully used in many others of the older mills.

12 The plan provided for inclosing the main drives with partitions of expanded metal and cement construction from 2 in. to 2½ in. thick depending on the story heights. A framework is constructed of expanded metal wired to 1 in. or 1¼ in. channel iron studs spaced 12 in. apart, and secured to the floor and ceiling. Longitudinal stiffeners of the same material as the studs are used. Where necessary, as in the case of a continuous partition of more than 10 ft., additional stiffness is secured by providing 2½ in. tee-bar uprights. On the frame so constructed portland cement mortar is applied by plastering to make a solid partition, all of the iron frame being embedded in the cement with the exception of the door jambs. These partitions, being comparatively light in weight, could be set up anywhere on the heavy mill floors without the necessity of strengthening them, al-

though where possible it was arranged to have the partitions come over the beams. Although this form of construction for partitions has been largely used and with satisfaction, it would be possible of course to employ some of the special forms of studding now on the market which combine the studs and lathing in one sheet of metal. Details of the construction used are shown in Fig. 3.

13 While in general the enclosures occupy only the floor space necessary for the main belts, it was endeavored to have them as

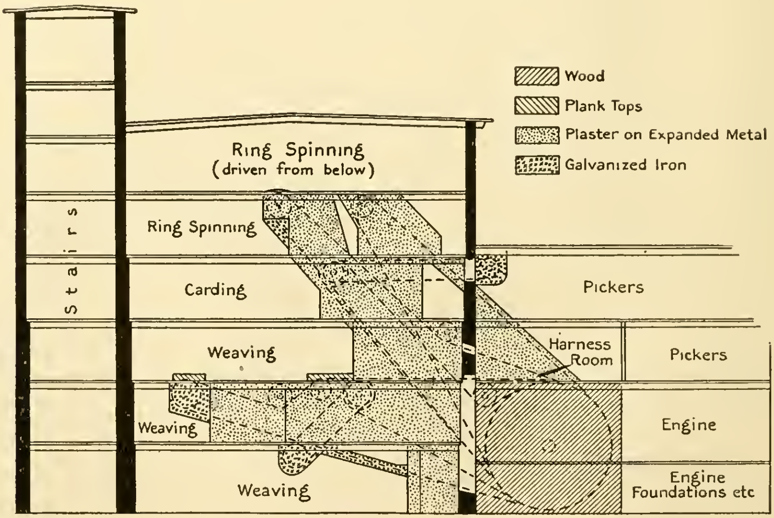

Fig. 4 Section showing Main Drive as now Protected by Fire Retardant Enclosures

roomy as conditions of machinery installation would permit, in order to facilitate inspection and repairs to the main belts. Provision was made for taking down the lineshafting without disturbing the body of the partitions, usually by placing the fire doors which gave access to the enclosure under the lineshaft, and providing removable wood tin-clad panels constructed like fire doors above the latter. The main bearings were generally left outside the enclosures and to accomplish this the panels in front of the pulleys were sometimes recessed.

14 It was also the endeavor to arrange these enclosures so that they would be as well lighted as possible by including in them windows in the side wall of the building or providing wired

glass windows in metal frames to admit light to the beltway from the room. Fig. 4 shows diagrammatically the completed work at the Fall River mill, and Figs. 5, 6, 7 and 8 are photographs of belt enclosures in different stories. The adaptability of the construction is evidenced in the sloping sides and offsets which it was necessary to make in many cases on account of crowded conditions in the vicinity of the main belts.

15 While there is no claim that these partitions are as efficient in withstanding the action of a severe fire as a brick wall would be, they are undoubtedly effective in preventing the dangerous draft up through an open beltway. In an actual fire in one of the mills where this construction was installed these enclosures were successful in confining the fire to narrow limits, and undoubtedly prevented a very serious loss.

16 *Stairways.* Where interior stairways are not properly enclosed in brick towers, it is possible to improve the conditions with enclosures of the same type of construction as employed in the beltway work, although it would be much better where the appropriation can be secured to build a standard tower of brick or concrete, especially if the mill is of any considerable height. Placing the stairs and elevators in towers projecting from the mill wall frequently results in a gain of valuable floor space.

17 The type of stair tower that has been developed in the factory buildings at Philadelphia is deserving of more general adoption as it combines with its functions of a stair tower that of a fire escape in the best sense. It consists essentially in a tower separated from the mill so that access to it can be had from the several floors of the mill only from an outside platform or from a vestibule which is open to air. Such a tower can never become filled with smoke from a fire in the mill. Many of the older mills in other sections of the country have stair towers that can be readily converted into towers of the Philadelphia type by closing the openings between the stair tower and the mill in the several stories and arranging for an outside platform in each story communicating from the mill to the tower.

18 *Elevator Enclosures.* We have also found the use of expanded metal and cement partitions practicable for enclosing elevator wells that were not properly protected in the original construction of the building, or where they have since been added. The necessary openings at such elevator shafts should be closed, preferably with wood tin-clad doors of the type which serve as

safety gates as well. Where space does not permit of the installation of such doors, rolling steel shutters arranged to be automat-

FIG. 5 HARNESS ROOM, SECOND STORY, DIRECTLY OVER FLYWHEEL SHOWING PROTECTION OF BELTS LEAVING WHEEL

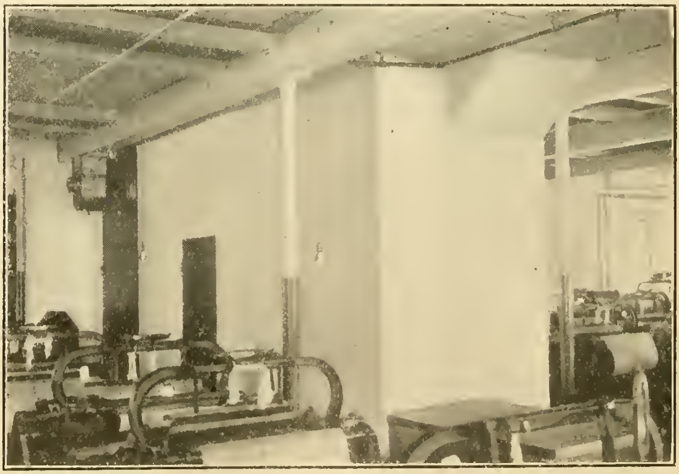

FIG. 6 WEAVE ROOM, SECOND STORY. NOTE FIRE DOOR WITH REMOVABLE PANELS ABOVE TO ALLOW ACCESS TO PULLEY ON LINESHAFT

ically operative by the melting of a fusible link, as well as manually, can be used providing the hazards of occupancy are not excessive.

19 *Other Uses.* The average cost of partitions of the construction advocated is from 30 cents to 33 cents per square foot.

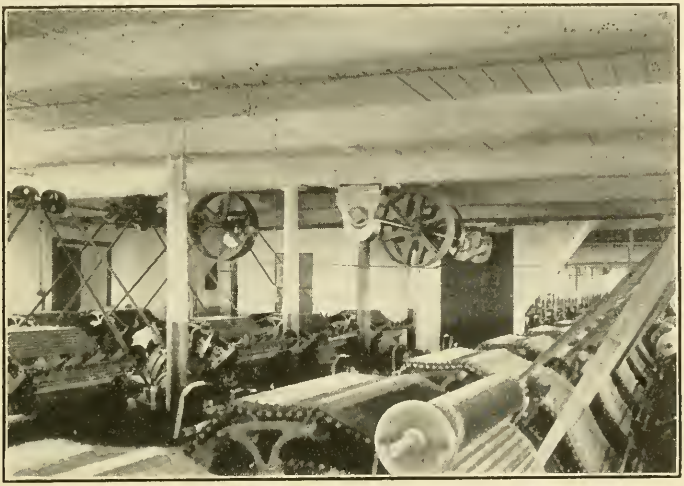

Fig. 7 Card Room, Third Story. Ends Sloped to Economize Space. Note Wire Glass Window and Fire Door with Removable Panels above

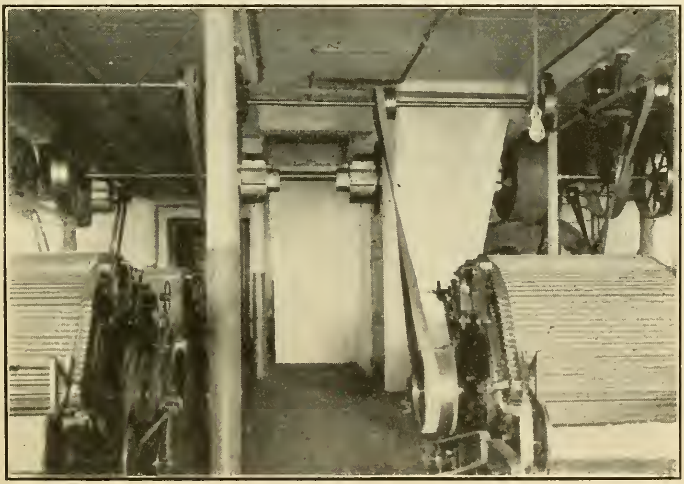

Fig. 8 Card Room, Third Story. End View of Belt Enclosure. Bearings All Outside

These figures are for the work in place and include a contractor's profit. These partitions have been used with superior results and

not greatly increased expense over ordinary forms of combustible construction for the purpose of separating special hazards from the remainder of a manufacturing room. For such purposes as the construction of bins to contain inflammable stock, the segregation of waste working machines, construction of lacquer rooms, etc., uses are constantly being found for this material in manufacturing works.

THE LIFE HAZARD IN CROWDED BUILDINGS DUE TO INADEQUATE EXITS

By H. F. J. Porter

ABSTRACT OF PAPER

Some seven or eight years ago the writer endeavored to empty a non-fireproof crowded factory building by a fire drill and found to his surprise that a stairway, when the attempt was made to use it by a large number of people entering it simultaneously at different stories, had a very limited capacity. He was unable to empty the building until practically a separate stairway from each story was introduced, and then the stream of people occupying each story flowed into its own stairway at the top and out at the bottom without colliding with any other people on their way down.

The loft factory buildings have so many stories that it is impossible to supply separate stairways for each story; consequently, some other method of giving safety to the occupants in case of fire must be adopted. The fire wall, bisecting these buildings from cellar to roof, allows all the occupants on one side of the wall to pass through the wall and to close the door, thus emptying that side of the building, which may be 20, 30, 40 or 50 stories in height, in less than a minute.

THE LIFE HAZARD IN CROWDED BUILDINGS DUE TO INADEQUATE EXITS

By H. F. J. Porter, New York

Member of the Society

Buildings in general are either non-fireproof or fireproof. The former can be compared to a pile of kindling wood out in the open, sometimes oil soaked and always ready to be set on fire. The latter are comparable to a stove full of fuel ready to be set on fire. In both cases the human occupants swarm around in the interstices in the pile of fuel, and as soon as the fire starts those caught in the fagots have to work their way down through the smoke and flames to the ground to save their lives.

2 Factory buildings in particular are sources of great danger to their large number of occupants, both on account of their non-fireproof construction and because of the obstructions to rapid egress, due to haphazard placing of machinery, furniture and partitions and the small number, size and character of the exit facilities.

3 Of late, there has been advocated the unrestricted use of fireproof construction in the buildings themselves and the author has recommended the development of a form of exit drill of the occupants of each building to determine if, in the case of danger, they could escape readily from the building and if they could not, the alteration of the exits until they could. By " readily " is meant within 3 minutes, for from many conferences it was found that people do not want, nor would it be safe, to remain in a burning building longer than that time.

4 The capacity of a stairway, if time is not a factor and a stream of people pours into it only at the top and out of it from the bottom, is unlimited; but if time is to be considered the capacity is limited by its cross-sectional area. In a multi-storied building with crowds of people on each floor trying at different points in its length to get on to one stairway in a limited time,

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the conditions are very different. If more people try to get on to the stairs from each floor than the section between that floor and the floor below will hold, a jam will occur so that the flow downward will cease. The capacity of this section is very limited.

5 A crowd of people does not flow like a liquid composed of round smooth molecules. Their soft bodies are angular in shape more like pieces of rubber with wires in them and they therefore interlock. Clothes present rough surfaces causing friction and if the stairway is narrow an arch is apt to form across it which can become an obstruction in case of pressure from above such as actually to burst the stair rail or enclosing partition.

6 The capacity of a stairway of the average height of from 10 to 12 ft. between floors and not less than 22 in. wide would be one person on every other step or 10 and 12 per floor respectively, and if the width is doubled (not less than 44 in.) so that two people can come down abreast, twice those numbers or 20 and 24. If a stairway has winders in it, its capacity is reduced 50 per cent. One person can descend a single flight of such steps 10 to 12 ft. high in 10 seconds, striking a gait which he can maintain for seven or eight flights of steps. After that he goes slower, making the tenth flight in about 11 or 12 seconds. Every person added in single file adds 1 second to this time. A double file takes no longer if the stairs are double width. Thus it will take 10 seconds for 10 or 20 people, that is, the full capacity of a flight of steps, to come down one story. The capacity of a stairway may be thus increased by widening it in multiples of 22 in. A crowd of people cannot be depended upon to come down more than ten stories. One or more of them will give out, and demand the attention of others. Those who do get down will be severely taxed. The total time required to empty a building is determined by the time required to empty either the floor farthest from the ground or the floor occupied by the greatest number of people.

FORMULA FOR EMPTYING A FLOOR BY ONE STAIRWAY

Number of couples (number of people divided by 2)	c
Time of formation in line after signal, seconds	10
Time one couple takes to march to top of stairs, seconds	10
Time each couple takes to pass through door at top of stairs, seconds	1
Number of stair flights (one less than number of floors)	f
Time of one couple to descend one flight of stairs, seconds	10
Time of one couple to go from foot of stairs to street, seconds	10

$$\text{Total time} = T = 30 + c1 + f10$$

Example Time of emptying 100 people from tenth floor

$T = 30 + 50 + 90 = 170$ seconds $= 2$ minutes, 50 seconds

Example Time of emptying a ten-story building with 20 people on each floor is the same as emptying 20 people from tenth floor

$$T = 30 + 10 + 90 = 130 = 2 \text{ minutes, } 10 \text{ seconds}$$

7 Tests of the capacity of fire escapes in a limited time gave the following results: A straight ladder, 2 per floor; ladder set at 50 to 60 deg. with the horizontal requiring people to go down backwards 3 to 4 per floor; stairs 30 in. wide, 10 to 12 per floor; and the modern outside stairway with a mezzanine platform 40 in. wide, 20 to 24 per floor, the same as an inside stairway. Fire escapes are usually so exposed to flames from windows opening upon them that they are more often fire traps than fire escapes. They should be prohibited by law and safer methods of escape provided.

8 In order to insure the safety of the occupants of a building in case of emergency one of two things has to be done: (*a*) there should be two stairways so that if one is cut off by flames or smoke the other can be used and the number of occupants reduced on each floor to meet the limited capacity of the part of the stairway between floors, or (*b*) the number of stairways increased so as to have two separate and independent stairways from each floor to the ground with its own exit from the building. People can then pour into the top of whichever one is not cut off by the fire and continue down and out at the bottom without colliding with those from any other floor. Fire drills installed under either of these conditions worked more or less satisfactorily, and the author tried unsuccessfully for years to have ordinances passed in New York City and legislation enacted at Albany, making them mandatory, but the expense of changes in the buildings and the idea of having employees walk out of a factory while manufacturing operations were under way, upon the sounding of an unexpected signal, did not appeal to factory proprietors as practical. It required holocausts in New Jersey, Pennsylvania and New York finally to bring about the legislation in those states.

9 As time passed, however, the author developed what might be termed an exit test in factories which presented the opportunity and found to his astonishment that almost without excep-

tion, exit facilities adequate for handling the regular number of occupants under emergency conditions, were lacking.

10 This situation has probably developed with the rapid growth of industry where a factory building had been built to accommodate a certain number of people, and then, as the business grew, more people were accommodated without realizing that each additional person became an increment of danger to all. Or, if the danger was at all appreciated, some means of escape from windows was supplied which might be anything from a rope to a ladder. After this condition had become general it crystallized into custom, and new buildings with exit facilities inadequate for their occupancy were designed, erected and accepted as safe. Ropes were followed by ladders, and these in turn by fire escapes which became in time an established necessity.

11 Engineers, when called upon to supply a mechanism, are expected to have it subjected to a working test, which it must pass before they get paid for it; but architects and builders have never been called upon to demonstrate by actual test that the facilities which they have supplied in their buildings for the purpose of emptying them under emergency conditions will actually work, and this notwithstanding repeated instances of panic congestion on stairs, of people being burned to death on fire escapes, of elevators sticking from the warping of their runways from heat, etc.

12 When subjected to test these exit facilities in many buildings have been found to be entirely wanting in adequacy, and when this fact was brought to the attention of those who were responsible, it has been surprising to find how readily they accepted the criticism. On the other hand, those who possess these unemptiable buildings are skeptical of such statements and unwilling to be persuaded that the buildings are not safe. They point to all the other buildings erected by reputable architects and builders and naturally are incredulous.

13 In order to empty these buildings, additional stairways had to be built and fire drills developed to take the people out. Such changes in the building are expensive, for two stairways have to be installed from each floor to the ground, so that if one is cut off by a fire, the other can be used. In many-storied buildings the number of stairways required becomes impractical. In addition fire drills are expensive to operate, for they involve not

only loss of time of operatives and a break in the continuity of the process of manufacture, but the actual going down stairs and return of people, some of whom may be lame, others affected by weak hearts or lungs, others anaemic or organically weak, reduce the efficiency of the working force for a very appreciable time. If the drill takes place at the end of the day this criticism might be modified slightly.

14 Such is the situation in the usual type of factory building to be found in the average town where ground is cheap, buildings large and stairways broad. Turning now to the loft building used for factory purposes, the conditions as regards emptiability are found to be very much worse and have to be corrected in a different manner.

15 Let us consider for the moment a one-story or ground-floor factory building with a doorway at each side, one of which is cut off by a fire. The people can march out horizontally through the other doorway and nothing will impede this horizontal exit except the size of the doorway. If this is 22 in. wide, a single file of people can pass out in an orderly manner at the rate of one person every second. If it is 44 in. wide, a line of people two abreast can pass out in the same time. One hundred people can make their exit through one 44-in. door, therefore, in 50 seconds, or say one minute.

16 Now put another factory on top of this one with one hundred people in it. The doorway at each side will have to open on stairways which lead down to the doorways constituting the exits from the factory below. Suppose a fire occurs on the floor below, cutting off one of these exits, the 100 people on the lower floor immediately proceed to make their horizontal exit, while those on the upper floor proceed to make a vertical downward exit to reach the doorway out of which those below are moving. The result is of course a collision, the stream of people from upstairs coming down upon the stream of people on the ground floor on their way out. This collision prevents both the up-stairs stream from coming down and the down-stairs stream from going out. There is a complete lock, and the building does not empty.

17 Not only have we put one factory on another in the case of our loft building, but we have piled factory on factory until we have from 10 to 30 and more, one on top of the other; and each employing from 100 to 300 or more people. In cases of

emergency as in the Asch Building fire, there are only two courses for the occupants: one is to burn to death, and the other to jump to death—"to burn up or jump down."

18 It is impossible to reduce the number of people per floor to the capacity of the stairs, say 24 per floor. Even if that number would be all that a business required, in case of emergency they would have to go down stairs, and it is a physical impossi-

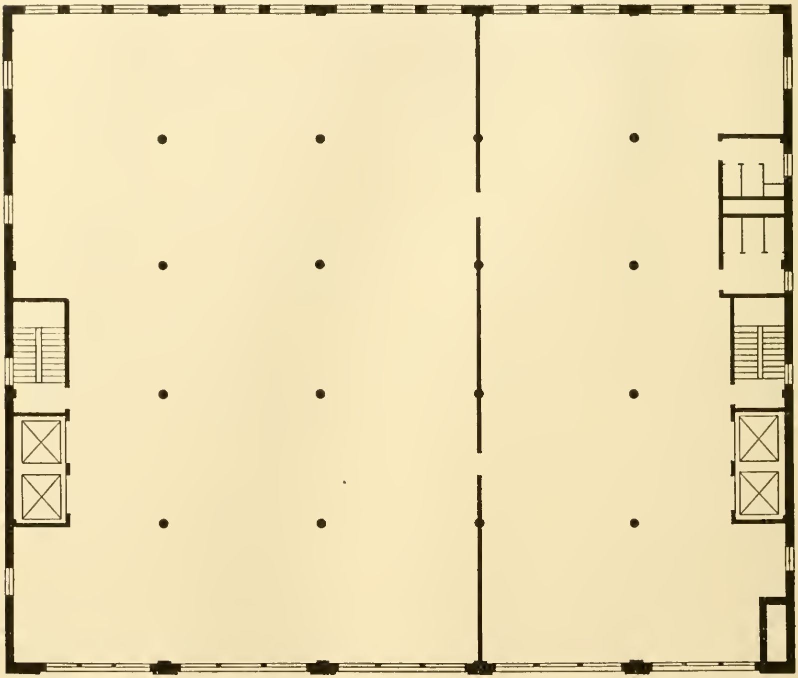

Fig. 1 Floor Plan of Typical Loft Building Showing Fire Wall with Doorways

bility for people to stand the exertion of a trip down more than ten stories without resting; and when they stop to rest they block the stream and obstruct its exit. Under these circumstances it is necessary to develop some other method for people in high buildings to secure safety. The following suggestion is offered to meet the situation:

19 It has been seen that a horizontal escape by people on the ground floor is readily secured. Let us see if a horizontal escape to safety for people at any height from the ground can be devel-

oped. Suppose a wall is built across the building from cellar to roof practically bisecting it in a way so as to have a stairway and elevator on each side. This wall should have at least two doorways in it at a considerable distance from each other and closed by self-closing fireproof doors (Fig. 1).

20 It is improbable that a fire will occur on both sides of this wall simultaneously. It could occur only by incendiary origin, and that would hardly be possible in working hours. Should one occur on either side, the people on that side would go through the doorways in the fire wall, close the doors after them and be perfectly safe. That half of the building in which the fire might be should be emptied in less than a minute if there were no more than 100 people on each floor to pass through one doorway 44 in. wide. If the principle of the horizontal escape presented by the fire wall is included in the design of new buildings a most satisfactory method of securing safety at comparatively small expense will be offered.

21 In every way possible the horizontal escape should be developed in old buildings and the vertical escape subordinated. Factory buildings adjoining one another may have doorways through their sides connecting them on various floors closed by fireproof self-closing doors, or may be connected by outside balconies built around the party walls; or, if of different heights, doors in the sides of one may lead out on the roofs of the others.

22 The fire wall bisecting the building as described makes practically two buildings, each provided with elevators and stairways. A fire on one side of the wall would be confined to half the building, and therefore the property loss would be reduced one-half. Only one-half the people would be endangered and have to move, and the distance they would have to go would be only one-half what it would be if they were on the ground floor of a building without a fire wall. They could remain on the same floor till the fire was extinguished, or could go down to the ground by the elevators operating under normal conditions.

23 The fire wall eliminates the necessity for a fire drill with its accompanying objections. Of course all buildings occupied by many people should have a fire alarm signal system in them to advise the people promptly of their danger. In buildings where there is a fire wall the signals should be arranged so that in case a fire should occur on one side of the fire wall on any floor, a bell on each floor on the same side of the fire wall would

ring, indicating on which floor the fire is. Then all the people on that floor and above it should pass through the fire wall and close the doors. Those below need not disturb themselves until the fire threatens them, and then they too can pass through the fire wall.

24 There are certain other safety devices which should be supplied in factories to protect the lives of the operatives from fire. One of these is metal-framed windows with wire glass. These are made so as to close automatically in case of fire, thus preventing the latter from spreading upwards from floor to floor outside side of the building.

25 Another safety device is automatic sprinklers which serve

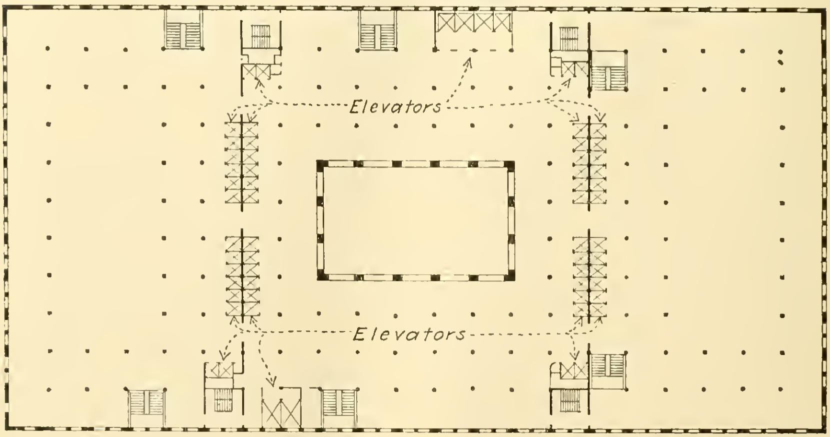

Fig. 2 Department Store Floor Plan Showing Present Arrangement of Fire Walls, Elevators and Stairs

to extinguish fires in their incipiency. All doors should be made to swing outward, and where they open on a hall or stair landing they should be vestibuled, so as not to obstruct the passage way. Sliding doors should be avoided if possible, as they are apt to stick or jam by pressure of people upon them.

26 Each floor of our typical loft buildings is say 100 ft. by 100 ft. by 10 ft. and therefore contains 100,000 cu. ft. of air. The laws of New York and many other states require 250 cu. ft. of air per person as a limitation of occupancy. This limits the number of people per floor in a building of this size to 400 and if the stairways were 44 in. wide (and there are none now over

36 in.) at most only 40 per floor could possibly go down them even if the other 360 would let them.

27 With the fire wall only 200 of the 400 people on each floor would have to move, and if there were two doorways in the fire wall at some distance from each other, they could reach safety through them in one minute, or if one were cut off by the fire, all could pass through the other easily in two minutes. More doorways can be introduced, and thus the time of exit could be lowered still further.

28 An effort is being made to increase the amount of air space required per person from 250 to 500 cu. ft., which would reduce the number of people per floor to 200, of whom only 100

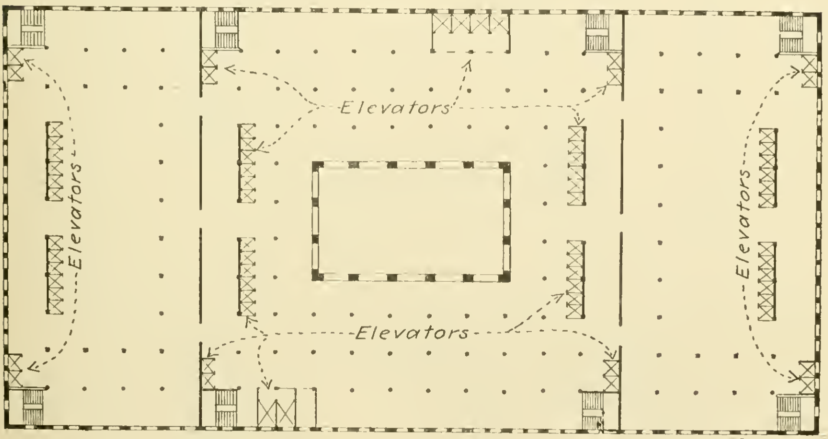

Fig. 3 Suggested Arrangement of Fire Walls, Elevators and Stairs for Department Store

would have to move, and they could easily reach safety in one minute.

29 The stairways and elevators should be inclosed in fireproof walls to prevent a fire on one floor continuing upward and setting the other floors on fire. The ceiling of the basement where the machinery is located should be fireproof, and should not be pierced inside of the building, so that a fire there would not reach the elevator shafts.

30 Fire escapes which are simply stairs and possess dangerous features not only of limitations as to size, but of accessibility for flames and smoke, should be looked upon as evidence of the

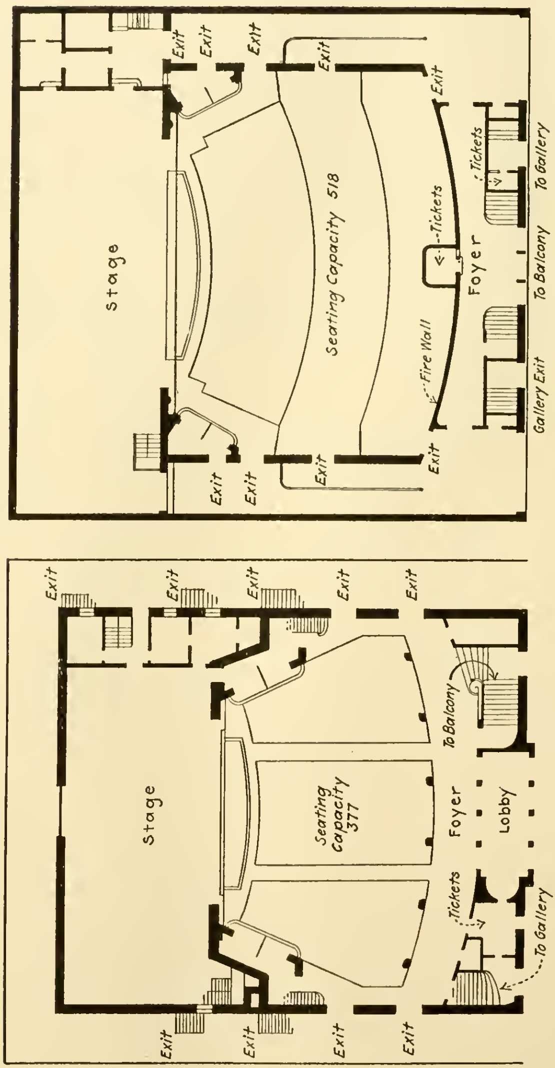

Fig. 4 Typical and Proposed Theater Plan Showing use of Fire Walls, Side Entrances and Exits

incompetence or ignorance, or worse, of the architect, builder, or owner, and prohibited by law under a heavy fine. They are not only dangerous to life by giving a false confidence in their adequacy for escape, but they destroy the appearance of the building. Our cities should be built without such architectural blemishes.

31 Fire escapes of the chute type are tubes with a smooth helix instead of steps. If the only opening is at the top they have considerable capacity. They soon rust, however, and at best are not to be considered seriously in comparison with other means of safe exit. People cannot enter them at different floors while a stream of people is passing down from above.

32 The smoke-proof tower, claimed to have originated in Philadelphia, is the latest improvement in the line of fire escapes. It is simply an enclosed stairway on the outside of a building, but cannot be reached except by going out of doors. Its special claim is that smoke and flames cannot get into it. It has, however, no more capacity than any other stairway, and as its approach is always open to the weather and its interior is always more or less dark, it is never used in ordinary service and becomes neglected. These monuments to architectural incompetency can be seen here and there filled with the dust and accumulated rubbish of every unused open space. When a time arrives for using them everybody has forgotten their existence. During the last year or two, notwithstanding the protests of many, a great many new buildings have been constructed, especially in New York City, with these monstrosities on them, and have been accepted by the Building Department in all seriousness.

33 The fire wall should be introduced into all buildings where the public congregates in large numbers. Large department stores, which on certain days are said to accommodate several thousand people per floor, are very dangerous places at present. A fire, or a panic without a fire, might cause a fearful tragedy. It is criminal for their owners to object to fire walls and offer as an excuse that they would obstruct the vista. Certain cities require fire walls in such buildings now as a property protection, and the vista is dispensed with without comment. The department stores of Philadelphia are so divided; John Wanamaker's new store there is divided by two such walls as shown in Fig. 2. The exit facilities in it, however, are badly

arranged, for the architect apparently did not think of the life hazard of its occupants, and designed the fire walls to protect property only. Fig. 3 shows how the building might be redesigned so as to be safer. It should be noted that the elevators are removed from the fire wall so that people trying to go down in them would not block the doorways of the fire wall and prevent others coming through them. The stairways are situated as far from the fire wall as possible and should be enclosed by fireproof partitions.

34 Churches, assembly halls and similar ground-floor buildings should have their floor fireproof and unpierced so that any fire occurring in the basement would not endanger the occupants of the main building.

35 Moving picture buildings, theaters, etc., should be redesigned (Fig. 4). People come out of them by the way they go in, and in case of emergency all crowd into the narrow aisles. These aisles should be turned across the room and lead directly to courts opening on the street in a way such that streams of people will not collide. The various balconies and galleries should have foyers behind fire walls with separate stairs and street exits so that patrons will not have to mingle with those making their exit from the lower floors.

36 Every school building should be divided by a fire wall providing a horizontal exit on each floor, so that the children will not have to be drilled to go down stairs in case of fire.

37 Hospitals where the inmates are bedridden, blind, lame, invalid, imbecile, or otherwise helpless, can be made safe by the introduction of the fire wall between wards, and in case of fire those who are bedridden can be wheeled on their beds through the doorways, and those who are up and about can walk through them.

38 Hotels and apartment buildings can so easily have a fire wall developed in them that it need only be referred to here in passing. Even the private residence where only a few people occupy a floor can be made safe in this way. The back stairway should be enclosed in a fireproof partition, and in case of a fire instead of everybody having to go down stairs through the smoke and flames, or having to jump from windows, the people on each floor have simply to pass through the fireproof door and go down stairs in safety. In large residences where there is a servants' quarters in connection with the back stairs, the build-

ing would be bisected and the people on either side of the wall would be able to carry their clothing and perhaps much household and personal property to safety.

39 Two years ago the National Fire Protection Association appointed a committee of which the author was a member to draft suggestions for the organization and execution of fire drills. This committee made its report to the annual meeting of the association held in Chicago last May, and it was adopted with slight modifications. A prefatory note to this report is as follows:

> Many so-called fire drills, outside fire escapes, and similar practices and devices are generally insufficient, often dangerous, and therefore misleading substitutes for rational exit facilities, and are a manifestation of improper design and construction of our buildings. A stairway connecting many stories will accommodate only a limited number of people. Stairways are, therefore, dangerous means of exit for crowds. Congestion is bound to occur in them when used under stress of excitement owing to their limitations.
>
> The primary object of the exit drill is to determine if the building is properly designed so that in the emergency of a fire its occupants would be able to effect their escape readily without the probability of injury from stairway or other congestion which inevitably causes panic. This test should be occasionally repeated to insure the continuous maintenance of safe conditions.

40 The author advocates legislation, requiring (*a*) that architects and builders be prohibited from designing buildings which cannot be emptied within 3 minutes after a given signal; (*b*) that the municipal authorities be required to institute an exit test in each building to determine, before it is accepted, if it can be emptied of its occupants in 3 minutes. If it cannot pass this test it will not be accepted and must be altered until it can pass the test. (*c*) Afterwards the proper authorities will be required to repeat the exit test from time to time, to see that the safe conditions originally established are maintained.

PRACTICAL OPERATION OF GAS ENGINES USING BLAST-FURNACE GAS AS FUEL

BY CHARLES C. SAMPSON

ABSTRACT OF PAPER

The paper discusses the following features upon which the operation of gas engines using blast-furnace gas as fuel depends: present methods, improved apparatus, gas mains, suggested improvements in scrubber designs, gas regulation, protection from freezing, signal systems, protection from explosions, and the value of operation records.

Under the engines themselves are considered the operators, air starting system, water jacket cleaning, cylinder oil, engine oil and engine oil systems, ignition and prematuring.

PRACTICAL OPERATION OF GAS ENGINES USING BLAST-FURNACE GAS AS FUEL

By Charles C. Sampson, Joliet, Ill.

Member of the Society

The question of the operation of gas engines using blast-furnace gas as fuel includes several important factors outside the actual operation of the engines themselves. It will therefore be aside from the present purpose to do more than state that the usual blast-furnace gas has the following composition:

	Per Cent
Carbon monoxide	23
Carbon dioxide	12
Hydrogen	2
Methane	2
Vapor of water	3
Nitrogen	58

and a calorific or heating value of about 900 cal. per cu. m., and gives a consumption of 3 cu. m. per i.h.p. in the engine.

CLEANING OF THE GAS

2 One of the most important of these factors and one which held back the general use of these engines many years is the cleaning of the gas. As delivered by the furnaces to the downcomer the gas contains normally from 3 to 10 grains of dust per cubic foot of dry gas, but at times of slips or other sudden changes in the furnace, it carries much more. For use in engines the gas must be cleaned at most to 0.02 grains of dust to satisfy the requirements of the engine builders, but even this figure is too high to satisfy the operating engineer since it is possible to clean the gas to 0.005 or 0.006 grains per cu. ft. with great benefit to the engines.

3 The method of cleaning most used at present has three stages: (*a*) dry cleaning to 1½ to 2 grains per cu. ft. which is

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always done by the blast-furnace department; (*b*) primary washing in static washers to about 0.15 grains per cu. ft.; (*c*) dynamic or mechanical cleaning in highly developed machines to 0.015 or less. The last stages are usually handled by the gas-engine departments, though as the furnace men realize more and more that a cleanliness of 0.2 grains per cu. ft. or less is of great benefit to the stoves and boilers they will take over the second stage, leaving only the final cleaning for the gas-engine department.

4 The dry cleaning is done in dry dust catchers, the standard design being a large diameter, vertical, cylindrical shell into which the gas enters tangentially near the top and leaves through a vertical outlet pipe which extends about two-thirds down from the top. These dust catchers remove the heavier particles of dust, but their efficiency is only about 80 per cent as they pick up, or perhaps do not drop, the finer dust which is carried on by the upward current of gas to the outlet.

5 The refinement of design in dry cleaners has advanced materially in the past three or four years, as shown in the modern apparatus resulting from the careful study of the problem. One of the latest of these is the centrifugal dust catcher shown in Fig. 1. This device makes use of the centrifugal separation of dust from the gas as it passes inward through a cylindrical spiral opening into a dust basin at the bottom. The gas enters at the top of the outside, leaves at the top of the inner end of the spiral and passes upward through an extension of the pipe around which it is wrapped. The gas passes free of all obstructions at the upper end of the spiral while the dust separated drops to the bottom through the open end. There is no tendency for the gas to pick up the separated dust and carry it out as is the case in the older types of dry cleaners.

6 It is frequently found that sudden changes in the direction of flow of the gas, as at water seals or other necessary bends in the pipe, are quite efficient in the removal of the dust. In one case gas carrying about 5 grains per cu. ft. passed through four sharp bends and gave all dust but about 2 grains per cu. ft. For this reason every part of the dry gas main where such bends are necessary can be made to assist materially in the cleaning of the gas, if pockets are added equipped with valves so that the dust can be conveniently removed.

7 Where long gas mains are necessary they can be made to add to the cleaning of the gas by building them in successive

lengths with sufficient rise and fall to allow the dust to settle in pockets at the bottom angles for cleaning. If the gas for any reason moves slowly in a long main the loss of heat through the pipe will probably reduce the temperature below the dew point and thus condense some of the moisture carried with the gas from the furnace and cause the deposit of wet dust which adds

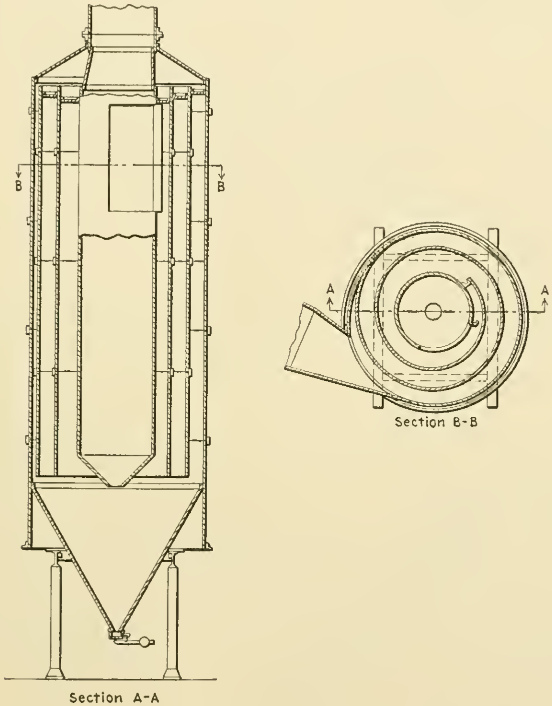

Fig. 1 Centrifugal Dust Catcher

greatly to the cleaning plant labor. This is especially apt to occur where two or more groups of furnaces supply one washing plant; the gas from the one with the lower top pressure will move slowly or even reverse its direction of flow at times, allowing excessive cooling and the resulting condensation. This condensation will begin when the temperature is reduced to 115 deg. to 120 deg. fahr. and will of course give more trouble in winter when the condensed moisture will freeze in the dust valves and drips and require continual thawing to allow its removal.

8 It is possible to keep the gas mains clean without taking them out of service if they are equipped with sufficient openings

to allow every part of the pipe to be reached with a stream from a high-pressure water system, and with valves or doors at all low points for the removal of the mud washed down. The mains near the furnace of course do not need this equipment as they can easily be designed to make them entirely self-cleaning, while it is quite necessary that long mains where condensation may occur be so equipped.

9 The present primary washers (the first stage of wet cleaning) are of the static scrubber type and include all those in which the gas passes through a stationary shell without moving parts, the water for washing being supplied either in spray or sheets. The spray and hurdle, Mullen, baffle, and rain type scrubbers come under this classification.

10 The spray and hurdle system is preferred on account of its better distribution of water, and since it is self-cleaning it needs inspection only after long periods of operation. Several of these scrubbers have been opened after from one to three years' service and in every case have been found perfectly clean and required no repairs whatever before being returned to service. The wood was in good condition as it is continually wet and oxygen does not have access to it to start decay. In the rain or baffle types the gas is more apt to channel and travel up one side of the scrubber and the water down the other.

11 It is important to secure uniform distribution of the gas as well as of the water in any scrubber. For the inlet a cone about two-thirds the diameter of the shell with a cone-shaped ring below it open in the center about one-half the diameter of the shell will give good distribution. These should both slope about 45 deg. to keep the mud from remaining on them.

12 Two outlets at opposite sides of the top are better than one on account of the deflection of the water by the gas currents if only one is used. This is particularly true if the water is sprayed by falling on spray plates as the gas current may then be strong enough to blow the water clear of the plate and thus entirely lose its effect. Spray nozzles are not subject to this fault but are not able to handle water that has much dirt in it without a great amount of attention.

13 In designing the scrubber bottom, its foundation and the basin and overflow for the outlet water, it must be remembered that while the usual working pressure will be from 6 in. to 18 in. of water, a slip will give pressure of from 40 in. to 50 in. for

a short time. A normal head of water of 36 in. from the bottom of the scrubber to the water overflow level with the basin walls 24 in. above this and an emergency overflow 4 in. below the top of the basin walls will care for slip pressure without blowing out any gas or overflowing the basin into the yard. The bottom of the basin wall will be self-cleaning if it has a steep slope and the outlet pipe is from the center of the bottom. The whole design of scrubber and basin must be examined to eliminate all

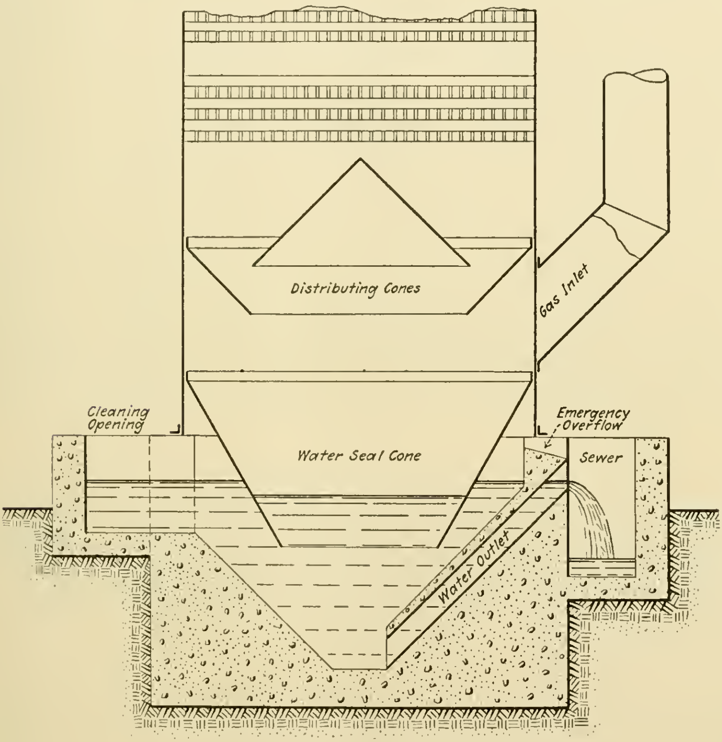

Fig. 2 Scrubber Bottom

places where mud can remain long enough to cake. Fig. 2 shows this arrangement of scrubber bottom.

14 Should the water overflow pipe be stopped even for a short time the heavy mud will settle to the bottom of the basin and when the overflow pipe is cleaned there will be such a quantity that even the extra head of water to the emergency overflow will not force it out. For this reason the forming of heavy chunks must be prevented as much as possible and provision must

be made for stirring the basin water both with hoes or rakes and with a stream of water from the end of a pipe which can be thrust into all parts of it. It will be found convenient also to have the pipe bent at the end so that the stream can be directed up the overflow pipe to furnish additional head for starting the flow when necessary, or a special pipe with return bend and short nipple to thrust down the overflow pipe itself will surely be able to start the flow.

15 The final stage in cleaning is done with mechanical scrubbers or washers. These are highly developed and the Theisen patented gas washer has been in the lead for several years though other types are now being worked out, their builders claiming better results with less water and power consumption than the Theisen. The Theisen washers require about 3 per cent of the power-plant output for their operation and from 16 to 18 gal. of water per 1000 cu. ft. of gas cleaned, which added to the 75 to 80 gal. required in the scrubbers makes the total from 90 to 100 gal. for the whole cleaning process. The newer apparatus, which are along the lines of the mechanical disintegrator, claim to use about 20 gal. of water per 1000 cu. ft. of gas for the whole cleaning process and to operate on less power than the Theisen washers.

HOLDERS

16 In blast-furnace gas-engine plants the engines are entirely dependent upon the continuous supply of gas from the furnaces; a 100,000-cu. ft. capacity holder can only be considered a pressure regulator with capacity for enough gas to allow retiring in good order when the gas supply is cut off for any reason. Thus in a 1000-kw. plant with such a holder the gas on hand would operate the plant only for about 25 to 30 minutes and should not be counted on for more than 15 to 20 minutes. This in an emergency would give time to notify the various departments using power and allow them time to prepare for a shutdown.

17 The quantity of gas consumed by the engines is regulated by the governor to suit the power output, but since they must be supplied with gas at uniform pressure for satisfactory operation, it is necessary to regulate the gas supplied by some type of gasometer. This is best done by a gasometer of capacity such that the pressure fluctuations are not noticeable at the engines, and since it is well to have an emergency quantity of gas the gas holder itself will meet both demands at once if supplied with

an efficient regulation valve. The holder will regulate the pressure perfectly between the maximum limit of the total quantity of gas that can be forced through the mains with the furnace pressure available assisted by the gas washers and the minimum limit of the leakage at the regulating valve.

18 There should also be the possibility of regulating the gas quantity at the secondary washers since at times of very light loads the gas pressure between the holder and washer may blow out drip seals or cause dangerous gas leaks. This can be cared

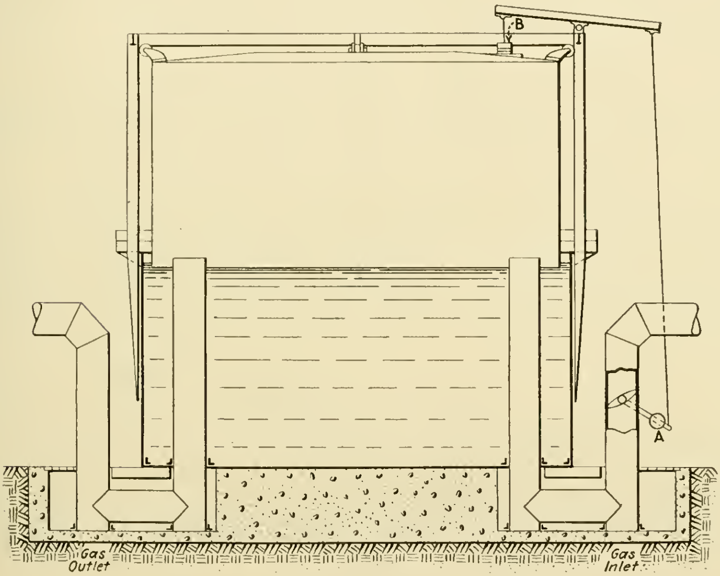

Fig. 3 Arrangement of Regulating Valve for Gas Holder

for by the installation of butterfly valves with quadrants either before or after the mechanical washers. The latter is to be preferred for then the gas remains longer in the washers and receives additional cleaning.

19 A good regulating valve at the holder is a butterfly valve attached by means of levers and cables to the holder bell so that it will remain wide open until the bell rises within a few feet of its upper position, and close gradually till at the highest position it is completely closed. The arrangement shown in Fig. 3 works satisfactorily. The weight *A* must be heavy enough to close the valve and the weight *B* must be heavy enough to open the valve and also lift the weight *A*.

20 All exposed water lines must be protected from freezing. This is especially true of the supply to seals, drips from the gas main, and any line that does not have a continuous flow. With good water separators after the secondary cleaning apparatus, freezing weather or even 8 deg. or 10 deg. fahr. below zero, will not cause trouble in the gas mains themselves, though any valves which may be nearly closed or which are closed part of the time must be carefully protected. The butterfly valve for regulating the gas should be enclosed in a tight box with steam coils to keep it in working order. This also is true of the valves at the gas-washing plant unless it is possible to install them within a heated building.

21 The water in the gas holder must also be warmed. The exhaust from the regulating valve coil will easily keep the holder water warm enough to prevent freezing except in the coldest weather (under 0 deg. fahr.), when it is usually necessary to supply additional steam through several nozzles arranged to set up a circulation of the water around the tank. These should be well down in the water or ice will form on the lower part of the shell and build in toward the center and prevent the lowering of the bell.

22 During the time the holder water is warmed it is important frequently to observe its temperature, if too hot it will charge the gas with water so that condensation and freezing will take place in the gas-engine supply pipes. When the water circulates properly in the holder it is not necessary to have it any warmer than 38 deg. or 40 deg. fahr., while a rise to 65 deg. or 70 deg. will give trouble.

23 If the gas holder is not visible from the gas-washing plant the operator needs a visible signal to give him its position, also an audible signal to inform him if it should lower beyond safe working position, the amount of the drop allowable before the audible signal operates being determined by the position of the regulating valve at the holder. The drop should be less than an amount to give a complete opening of the valve. The gas-washer operator should have telephone connections with the engine room, besides the usual whistle or bell signals which are used to notify him of the starting or stopping of engines. He should also be in close touch with the blast-furnace department in order that any change in the gas supply can be known in advance.

RELIEF DOORS

24 In all gas-pipe lines so-called explosion doors are installed. These are as a rule useful only for access to the main for cleaning, usually being made of cast iron and hinged; on account of their weight and method of attachment the moment of inertia is so great that they will not open quickly enough to prevent the destruction of the main in which they are installed. Any gas main that will support itself over the span usually employed will easily stand any pressure that can be produced in the cleaning plant, and the use of these valves or other relief valves is not necessary. The inconvenience of escaping gas makes it advisable to design them as cleaning doors only, and to arrange them with a clamp fastening to avoid this inconvenience. If it is thought necessary to instal explosion doors or valves I would suggest the use of sheets of light material arranged in frames so that they will be blown out should an explosion occur in the main.

25 The best protection from explosions is careful operation, especially to guard against a reduction of pressure of gas at the furnace side of the cleaning plant due to no air being drawn into the main at the stoves, and to see that no piece of apparatus is put in service with air trapped so it can be mixed with the gas and sent along to the engines.

RECORDING INSTRUMENTS

26 Thermometers and pressure gages for indicating the temperature and pressure of the gas: entering the cleaning plant, between the primary and secondary washers leaving the latter, and before and after the gas holder, form important parts of the gas-cleaning system. The ordinary gas works thermometer with a stem reaching about 8 to 10 in. into the gas mains are to be located at each of the above points, while pressure gages of the U-tube type with inches of water as a measure of the pressure can be located in the gas-washer building and connected to these points by 3/8-in. or 1/2-in. gas pipe. Recording gages should be used in connection with the indicating water column for the gas pressure at the entrance to the cleaning plant and in the gas main leading to the gas holder.

LOG RECORDS

27 The successful operation of the gas-washing plant is very much advanced by the proper understanding of the meaning of the variation shown by these thermometers and gages. For this reason it is important to keep a record of these variations on

carefully designed daily log sheets with at least eight daily notations. The gas-washer operator soon learns to interpret the gage and thermometer changes, and will often foretell serious trouble by such understanding. For instance, the partial filling of a water seal is indicated some time before it will cause trouble by the swinging of the water in the U-tube, this movement being so markedly different from any other that he knows at once the trouble and from the location of the gage can easily tell which seal is filling.

28 The daily log sheets should have space reserved for the operator to note any unusual occurrence and the work done to keep the plant in condition. It should be in fact a complete report of each day's work to the engineer in charge, keeping him in close touch with the changing conditions in the gas-cleaning system.

ENGINE STARTING

29 A second most important factor in successful gas-engine operation is good engine operators, and the same characteristics which are valuable in steam-engine operators are valuable in the gas-engine engineer.

30 The operation of the engines themselves is exactly similar as far as the running gear is concerned and it is only the fact that the gas engineer is fireman as well as engineer that makes it necessary that he be more alert and watchful. Economical operation of gas engines on the same account requires that the engine operator must have his sense of "the feel of the machine" well developed.

31 Compressed air at from 150 to 200 lb. per sq. in. pressure has proved satisfactory for starting gas engines and is especially desirable on account of the ease with which a suitable quantity can be stored under pressure ready for use at any time.

32 In a starting system of 2000 cu. ft. capacity the air pressure is lowered about 20 lb. in starting one 3000-kw. twin-tandem unit, and since 150 lb. pressure is sufficient for a start there is a possibility of at least three starts from 200 lb. initial pressure, which is certainly sufficient to get under way even during the excitement of an emergency shutdown.

33 Record was kept of the pressure drop in starting an 1800-h.p. twin-tandem Allis-Chalmers engine from an air system having two tanks of 1100 cu. ft. capacity each. This record included 19 starts, 16 using the full capacity of the system and three with

one tank out of service. This record is plotted in Fig. 4 the pressure in the system being shown as ordinates and the pressure drop as abscissae; the 16 starts with complete air system in use are indicated by circles and the three that were made with one of the air tanks shut off, by crosses. It may be noted that the quantity of air required to start the engine was about the same, regardless of the pressure in the air tanks.

34 The necessary capacity of air tanks and air compressors for a given plant depends upon the number and size of engine units, and the frequency with which they may need to be started. After the engine operator becomes familiar with the operating

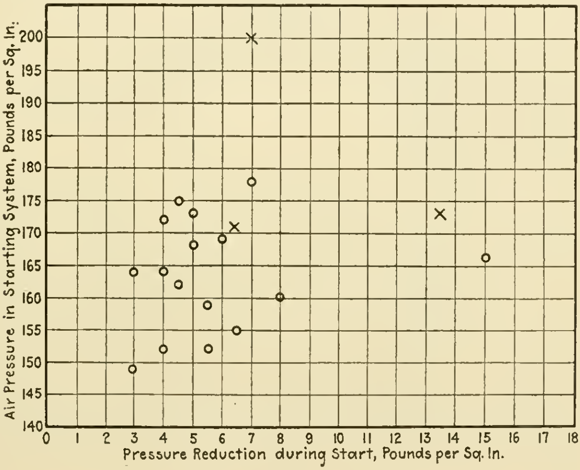

Fig. 4 Record of Pressure Drop

peculiarities of the engines he should be able to start them at intervals of from 4 to 8 minutes and not lower the air pressure more than the compressor can make up in that time, if an engine lowers the pressure 8 lb. per sq. in. in a 2000-cu. ft. capacity system, the compressors should compress 8/15 of 2000 = 1060 cu. ft. free air in the maximum time allowable between starts or say 10 minutes. This would require two 106-cu. ft. compressors.

35 For the ordinary blast-furnace gas-engine plant of from three to six engines two air compressors of 100 cu. ft. capacity and air tank capacity of 2000 cu. ft. are quite sufficient, while for more than six engines the compressor capacity should be increased rather than the tank volume. At least one of the compressors must derive its power from some source outside of the

gas engine in order to be able to start the plant if all units should be down.

36 It is important to keep the water jackets thoroughly clean and the item of jacket cleaning should appear regularly in the engine operation schedule. This cleaning requires careful attention since, with the class of labor usually put on this work, it will be slighted in the places where the most care is needed.

LUBRICATION, CLEANING OIL

37 The question of lubrication is one of so many variations I can only say that for general lubrication of such as main bearings, crosshead and crankspins and crosshead slides where the rubbing surfaces are at room temperature, an oil of the following physical characteristics has given excellent service:

Specific gravity	.888
Viscosity (Tagliabue)	210 at 70 deg. fahr.
Cold test	35 deg. fahr.
Flash temperature	435

38 This service also includes satisfactory separation of water and dirt by settling and filtration. On account of the almost certain mixing of water from the cooling system with the system oil, it is necessary to provide means of separating the water and oil in the filtration process and it can be done thoroughly only by heating the oil to about 160 deg. or 190 deg. fahr. and giving it time in a quiet condition to allow the separation. A large part of the dirt will settle with the water. Such that does not, must be removed by filtration through fine cloth either of organic fiber or of fine wire. The latter is more to be desired because of the ease with which it can be cleaned.

39 A good oil-cleaning system giving excellent satisfaction consists of one 1500-gal. water-separating tank, shown in Fig. 5, with a heating coil over which the oil flows as it enters on returning from the engines, and an adjustable automatic water overflow to discharge the separated water, two settling tanks of the same size through which the oil passes in tandem to allow time for quiet settling of dirt particles, and a filter unit with 20 filter bags, 10 each in two filter tanks.

40 An extra tank is used when either of the other three is out of service for cleaning. An auxiliary tank of about 200 gal. capacity is used for "boiling up" the sludge taken from either of the large tanks or the filters at time of cleaning as well as such dirty oil as can be drawn off daily from the bottom of the overhead oil tank.

41 This system is shown in Fig. 6. The oil from the engine drips enters tank *A* over the steam coil, flows down through the inner cone then up and out the overflow to *C* and *D*, thence to the filters *F* and *G* through *E*, which is also a water separator. The clean oil is pumped from the filters by one of the pumps at *K*, which are in duplicate, to the overhead engine supply tank in which the quantity of oil on hand is shown by an index on a large gage visible from the engine-room floor. Gage glasses on

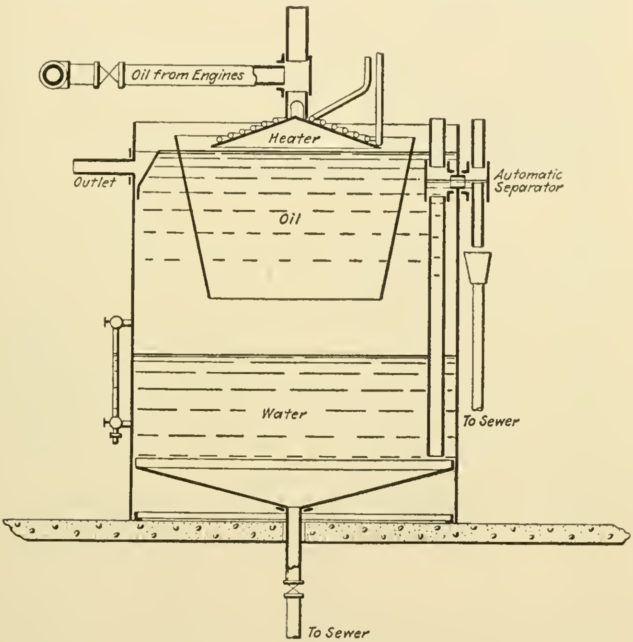

FIG. 5 WATER-SEPARATING TANK FOR OIL-CLEANING SYSTEM

each tank show the level of the line between the oil and water both as an operating convenience and as a means of checking the quantity of oil used during the month. The separated water flows down the inside of the cone in *A* to the bottom of the tank from which it flows through the automatic overflow *H*. The nipple in the tee at *H* is adjustable so that the water in *A* can be held at the level found best in operation.

42 A part of the dirt is oil-coated so that it floats between the water and the oil and will accumulate until its removal is necessary. The oil from the engines is then turned into tank *B*,

the supply to C and D being kept up by stopping the water overflow and filling A with water as long as good oil flows out. The water is then drawn off to the sewer and the sludge pumped into the boiling tank J where as much oil is reclaimed as possible. The other tanks are cleaned in the same way. There are pipe

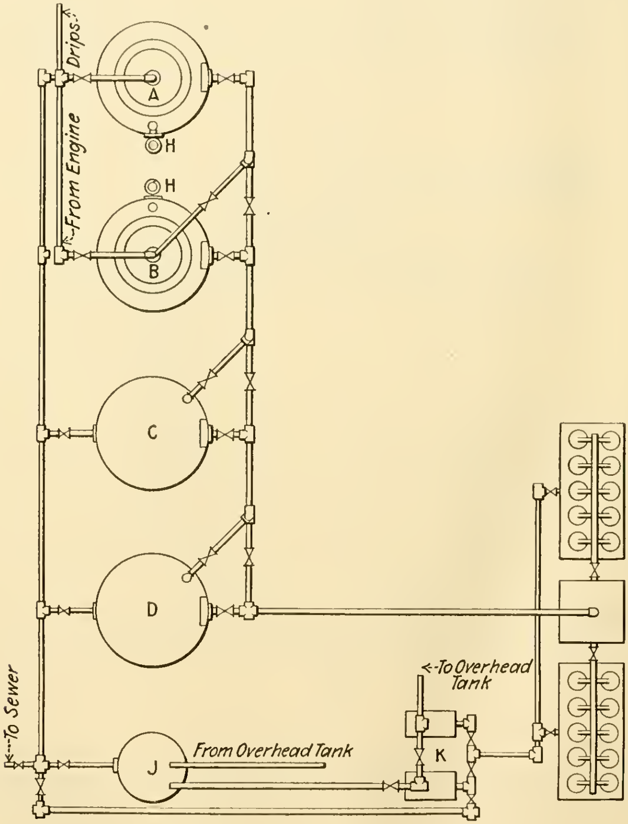

FIG. 6 OIL-CLEANING SYSTEM: A AND B, WATER-SEPARATING TANKS; F AND G FILTERS; J BOILING TANK

connections from the bottom of all tanks to one of the pumps, also from the discharge of this pump to the tank J.

43 Such an oil system will keep the oil clean for a plant circulating 500 to 600 gal. per hour. Of course some oil is lost through leakage at the engines, and some is wiped up in keeping the engines clean, but the addition of new oil need not amount to more than 100 gal. per month. In blowing-engine plants where the engine oil is drawn into the blowing cylinders from mechan-

ically operated valves the oil consumption will not be so low unless good oil separators are installed in the cold blast mains arranged to discharge this oil back into the oil system.

44 The cylinder oil question is also one of many opinions. The varying cleanliness of the gas, hardness of cylinder walls and piston rings, piston speeds, mean effective and maximum pressures all have their influence on the action of the cylinder oil. An oil showing a specific gravity of 0.902; viscosity (Tagliabue) of 78 at 212 deg. fahr., and a flash temperature of 380, gave excellent results in a gas blowing-engine plant where the dust was low (0.01 or less) and piston speeds less than 600 ft. per min., and was not satisfactory in another, with 0.012 dust and piston speeds of 850 ft. per min. In the latter case the oil was replaced by one of specific gravity, 0.920; viscosity, 203 at 212 deg. fahr.; and flash temperature, 502, and immediate improvement was shown.

45 With the lighter oil the cylinders were not dry in any part though they did show more wear than was expected for the time in service, the machining marks in the bore being almost invisible after three months' operation.

46 The cylinder oil can be put in a tank in the basement and piped to all cylinder oil pumps by using compressed air at 15 lb. per sq. in. This provides opportunity for the installation of oil meters to keep accurate account of the oil used on each engine, or the supply tank may be equipped with graduated gage glass and record kept of the supply to the whole plant.

IGNITION

47 The mechanically operated igniter is much to be preferred over the magnetic type. The current supply should be from a source not liable to fluctuation, such as that from a motor generator set that supplies current to the ignition system alone and arranged in connection with a storage battery so that should anything happen to the motor generators the battery would take up the load, automatically signaling the operator. The location of the ignition plugs is important, since an explosion on one side only of the piston will force it to the other side and cause it to strike the cylinder wall. This is easily apparent in cylinders having the combustion chamber at the side and the effect of one-sided explosions can be seen when one of three equally spaced igniters is not working.

48 Premature ignition is usually caused by excess hydrogen in the gas, and will occur when the quantity of hydrogen reaches 4.6 per cent, depending also upon the cleanliness of the cylinders. This prematuring is one of the first indications of leaking cooling plates in the furnace and the gas-engine operator will often be able to inform the furnaces of this condition before they learn of it themselves. When a furnace has the wind off for casting, the water pressure in the cooling plates is greater than the furnace pressure and the water enters the furnace and is immediately dissociated, the oxygen being consumed by the coke leaves the excess hydrogen in the gas. When the wind is put on again this gas, rich in hydrogen, is sent along to the engine causing prematuring.

MISCELLANEOUS INFORMATION

49 The pistons of the early large gas engines were of cast iron but these gave considerable trouble by cracking because they were not properly ribbed. Several builders changed to cast steel, but found they gave trouble either by cutting the cylinder walls or by beading over and binding the rings. Cast iron was again resorted to with an improved design. In the cast-steel pistons also the movement of the rings widens the grooves so that in a short time there is too much clearance which necessitates turning the grooves and making new rings.

50 Cast-iron snap rings of uniform cross-section give better service than any other type. This has been learned after many attempts to design a complicated ring, the designer believing a ring to hold gas-engine pressure would be more difficult to make than one for steam-engine pressure.

51 Piston-rod packing furnishes one of the difficult problems for the designer and also for the engine operator. A good packing must be simple in design and, as in the case with the piston rings, the forms with the fewest parts seem to give the best service. Both cast iron and babbitt have given good results. The success or failure of this part of the engine depends largely upon its cleanliness and too much care cannot be used in assembling it to insure its proper application.

52 The engine-room basement has not received the attention it deserves. Two items the designer of any power plant will do well to consider are: make the engine-room floor high enough over the basement floor to allow 6 ft. clear under all suspended

pipes, and have the basement floor slope enough for rapid drainage (at least 12 in. for 100 ft.). A dry basement with plenty of head room is easily kept clean and a clean basement is a great help in keeping the whole room in good condition. Ventilation and lighting are also more easily accomplished in a high basement.

53 The question of safety of the employee in all occupations is at present a live one and is to be considered in the engine room as well as in the rolling mill. Safety demands the elimination of all dangerous conditions by covering gears, guarding flywheels, generators and crossheads, enclosing electrical apparatus and keeping all gas pipes tight and free from leaks. The men must be trained to watch out for their own and their fellow workmen's safety. It is just as important that the lives and limbs of the engine crew be protected as it is that the cost of electricity should be low.

54 Complete records of operation are invaluable as it is only by the study of accurate record of the actual happenings that we can hope to improve. It is not possible to trust to memory for a comparison of the results of different types or arrangements of apparatus.

55 A daily log of the various pressures and temperatures must be kept to learn whether the plant conditions are changing and to know the cause of these changes. Any unusual occurrence or the regular recurrence of repairs noted on the log sheets puts the information regarding the plant where it can be used in predicting and preparing for the future. Not only should this information be kept daily but it should be collected and averaged monthly and yearly for the comparison of month with month and year with year. Much of the engineering information is best shown graphically, for a sheet full of figures does not give a true conception of the actual conditions.

56 The original information is necessarily furnished on the daily log sheets written by the shift engineer and he should be supplied with a copy of the resulting data sheets. He is just as much interested in the power plant as is the chief engineer and this information cannot be placed anywhere to do more good than with the engine operators. The rate of progress in the gas-engine field depends entirely upon the rapidity with which engineers are able to gain understanding of this machinery and the collecting and compiling of these records is of the greatest service for this purpose.

RAILWAY SESSION

STEEL PASSENGER CAR DESIGN

Papers and Discussion presented at a Meeting held in New York, April 8, 1913, conducted by the Sub-Committee on Railroads of the Committee on Meetings, the New York Local Committee Coöperating

PAPERS

INTRODUCTION TO GENERAL DISCUSSION OF STEEL PASSENGER CAR CONSTRUCTION

By H. H. Vaughan, Montreal, Canada
Member of the Society

The advent of the steel passenger car has brought with it many new problems and an opportunity for more diverse opinions than any other change that has taken place in car equipment. The construction of the wooden passenger car developed along fairly uniform lines. The varieties of framing were few and the differences unimportant, while the introduction of steel platforms, wide and narrow vestibules, reinforced end and sill construction and similar improvements occurred gradually, and with practically similar designs on all railroads. The change from wood to steel in freight car construction resulted in the abandonment of designs that had almost become standardized and the introduction of many new types, but in this case the principal problem, other than that of obtaining satisfactory designs, has been the extent to which it was advisable to use composite or all-steel construction.

2 In the case of the passenger car, the types to be employed will probably not be changed by the substitution of steel for wood. The increase in capacity that has taken place in freight equipment cannot be duplicated in passenger cars, and there appears to be no tendency at present toward any increase in length or carrying capacity. The questions that now confront us relate rather to the design and construction of cars of the present type and of the materials that may be advantageously employed in place of the wood which has been used for so long. They are complicated by the necessity of providing for greater safety for the passengers than was secured in the wooden car, with an equal degree of comfort and the difficulty of anticipating the behavior of this new equipment in the case of accident. Certain difficulties such as the best systems for heating, lighting and ventilation, are common to both steel and wood construction, and improvements in these matters pertain to general progress

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rather than the use of steel construction. The following list, while probably incomplete, outlines in a brief way the important variations that must be considered in deciding on the preferable construction of steel passenger equipment:

Framing	Steel underframe	
	All-steel frame	Center girder Side girder
Outside finish	Plated	
	Sheathed	
Roof construction	Clearstory	
	Circular	
Inside finish	Steel	
	Wood	
End construction	Design and strength	
Floor	Design and material	
Insulation	Material	

No doubt questions of equal importance have been omitted, and in many cases those mentioned require careful consideration with regard to degree, as for instance, the strength of the framing or the thickness of the insulation. The list illustrates, however, the diversity of possible solutions of the preferable steel passenger car, and the following personal opinions are presented for the purpose of opening the discussion:

3 The steel underframe does not appear to be a satisfactory or permanent development. There is but little saving either in weight or cost over the all-steel construction, and it is difficult to see how the same strength in case of accident can be obtained. Experience will show whether the wood superstructure can be secured in such a way as to prevent working as the car gets old, but as it cannot be arranged to carry any weight this appears questionable. It can hardly be regarded except as an intermediate step between all-wood and all-steel construction.

4 In all-steel construction the side-girder car presents advantages, but as in freight construction, both types will probably persist. The side-girder construction obtains greater strength in the side framing without superfluous weight, and it is possible that greater framing strength may prove necessary. With equal strength of side framing the side-girder car may be made lighter than the center-girder type, and the weight of steel passenger cars is one of the most serious problems to be faced by any railroad not having a level line. American passenger equipment was already excessively heavy per passenger carried

with wood construction, and the use of steel has increased this weight from 10 per cent to 20 per cent, which is a most serious matter. Apparently side-girder cars as so far constructed have a decided advantage over the center-girder type in their light weight and greater strength in case of accident tending to crush in the side of the car. This will probably lead to the use of this type on roads on which weight is of importance.

5 In spite of the many advantages of the sheathed car in case of construction and maintenance, it appears that the cost and weight of the additional metal will prevent its extensive use. This question is chiefly one of appearance and convenience, and is of minor importance.

6 The circular roof has been extensively introduced on steel passenger cars on account of its lightness and simplicity of construction. It has the objection that deck sash ventilation cannot be employed. The Pullman Company while using the clearstory roof have, however, discontinued the use of deck sash ventilation, so that evidently in their opinion this objection is not important. The deck sash is, however, of value in a standing car, and when properly screened is certainly advisable in hot weather, especially when the road is dusty. The Canadian Pacific Railway have compromised on this question and are using a roof of approximately circular form with deck sash. The strength and simplicity of the circular roof is retained with the ventilating qualities of the clearstory type.

7 The preferable material for inside finish is a matter for future decision. With the ample protection afforded by a steel car against accident, there does not appear to be any objection to wood inside finish on the ground of safety. It is more ornamental than steel and a better insulator. Probably on no question in passenger car design is opinion so divided amongst both railroad and carbuilders. There is today very little difference in cost, and it certainly appears probable that in the future the tendency will be to adopt steel interior finish if not entirely, at any rate to a great extent.

8 The construction of the ends of the cars has received considerable attention, and the strength now usually employed is enormously greater than anything attempted in wood construction. Several excellent designs have been devised, which will probably be referred to in another paper.

9 The floor construction in steel cars is entirely different

from that in wooden cars, and is usually of metal covered with a flexible cement. In constructing a sample car for the Canadian Pacific Railway the writer used in addition an underfloor covered with insulating material, and covered the cement with ½ in. of cork. This car was also exceptionally well insulated at the sides, 2 in. of cork being used next the outside plating. Tests during the past winter have shown that this car is actually warmer than the ordinary wooden car, the same amount of heating surface being used in both types. The floor was tested by taking the temperature of water standing in cans on the floor, there being no practical difference between the results in the wood and steel cars. The question of insulation is an important one, both in hot and cold weather, and while other insulation might no doubt be equally effective, it is interesting to be able to advise that with proper insulation there is no question of the steel car being satisfactory.

PROBLEMS OF STEEL PASSENGER CAR DESIGN

By W. F. Kiesel, Jr., Altoona, Pa.

Member of the Society

Whenever it becomes necessary to adopt a policy representing a complete departure from existing policies involving a new theoretical structure from foundation up, many problems, some entirely new, have to be solved. The increasing cost of lumber, the desire for longer and stronger cars, and other considerations indicated the desirability of making a determined effort to develop a satisfactory steel passenger car. The object of this paper is to review a few of the problems encountered, beginning with:

2 *First: Can We afford It, and What will It cost, compared with Wooden Cars?* Tentative designs were prepared and carefully analyzed by a committee of representatives of carbuilders and railroads. The summary of their report was that at first steel passenger cars would cost approximately 20 per cent more per passenger than wooden cars of the best existing types, but that the steel cars would probably cost much less to maintain. They also reported that on account of the increasing cost of good lumber, and the probable decreasing cost of manufacturing steel cars, not many years would elapse before the cost of steel cars would be no more than, if as much as, wooden cars. Those who have been in close touch with the development of the steel-car industry know that at the present time steel cars cost no more than equivalent wood cars.

3 *Second: Shall the Cars be All Steel, or Steel Frame with Wood Lining?* Differences of opinion still exist on this point. Both types of car have been built, and each has strong advocates.

4 In the all-steel car the steel lining can be securely riveted to the framing and adds somewhat to the strength of the com-

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plete structure, but as steel is a good conductor it carries away the heat of a body coming in contact with it, and, therefore, will always feel cold, even when the temperature in the car is sufficiently high. Satisfactory results have been realized from the use of a double steel lining between seats, forming a hot-air duct, extending from the heater pipes to the window sill, with outlet through small holes in the lining proper, located immediately below the window sill in the lining proper.

5 Wood lining requires considerable wood furring, and adds weight to the car without adding to the strength. As the steel frame of a long passenger car may vary as much as ½ in. between extremes of temperature, it is necessary to make allowance in the construction of the wood lining for this variation in length. As a car with metal lining riveted to the framing has the advantage in strength, weight, and cost, it will gain in favor; in fact, it would be at present universally preferred if all railroad shops had practical experience with steel lining, and the necessary proficiency and machinery for its manufacture.

6 *Third: Insulation.* Three general principles have been used for car insulation:

- *a* Wood lining.
- *b* By placing insulating material on the outside of steel lining.
- *c* By placing insulating material on the outside of the steel lining, and on the inside of the steel sheathing.

7 Experiments have been made also with other methods, such as completely filling the space between sheathing and lining with block magnesia and magnesia cement. The problem that presents itself is: Given a car body with a comparatively smooth exterior surface protected by several coats of paint, double walls, painted on both sides—if of steel, isolated air spaces, rather large in volume, between the walls, an inside cubic volume in which the air must be continually renewed, and a window surface of about one-third of the area of the side walls. When single windows are used the air close to the windows is cold in winter, and warm in summer. Double windows improve the situation materially.

8 Experiments made to determine the difference between a wooden and a steel coach, with doors and windows closed, standing on a siding exposed to the sun in hot, summer weather, showed a difference of one to two degrees in favor of the wooden

coach. One day's readings showed an average of one degree difference in temperature in favor of the steel coach, which had insulation only on the outside of the lining. The results of several years' experience indicate that the lining must be insulated throughout, and, if the spaces between lining and sheathing are properly isolated, little is gained by insulating the sheathing, and more will be gained by the use of double windows. Furthermore, the heat lost in cold weather by conduction through and radiation from the walls, in cars with insulation on the lining alone, is negligible when compared with the heat carried off by adequate ventilation.

9 *Fourth: Protection and Safety of Passengers.* This problem involves providing adequate strength for carrying the load, also to prevent collapse or crushing in wrecks, and efficient brakes.

10 The laws governing load-carrying strength are well known, but this cannot be said of the laws governing wrecks. Each wreck forms a separate study, and we seldom find two that can be placed in the same class. The study of wrecks, which, unfortunately, do occur, shows that the car underframe must be reasonably strong to resist end strains, that the ends of the superstructure must be reinforced with strong vertical members, and that the car must not collapse when rolled down an embankment. The gradual elimination of crossings at grade has materially decreased the danger of strains directed against the sides of the car.

11 Early experience with steel freight cars showed clearly that the men handling cars in yards believed that all cars built of steel could withstand much rougher handling than wooden cars. Although the resultant damage to both kinds of freight cars had its disadvantages, it developed a better knowledge of the relative value of steel and wood in car construction, led the designer to abandon the basis of ultimate strength of the material, and to substitute the basis of elastic limit, and finally to select a ratio of 4 to 1 as the relation of the elastic limit of steel as used in cars to that of good timber.

12 That not all designers of steel passenger cars had the advantage of this knowledge, or profited by this experience, is evidenced by some of the car designs which have been illustrated in the technical papers in the past years and which proved fundamentally defective.

13 Selecting from the last generation of wooden cars one used in heavy trunk line service, with four 5-in. by 9-in. wooden sills bunched together near the center, and so located as to be nearly uniformly affected by the end strains, steel platforms with draft gear securely attached, and the remainder of the car to correspond, the analysis of its end-shock resisting capacity leads to the consideration of the elasticity of the material, the transverse bracing preventing buckling, the concentration of strength near the longitudinal center line of car, and the reinforcement at the platforms.

14 The wooden car, therefore, meets many of the requirements enumerated before. A corresponding steel car should have a center sill area of 45 sq. in. braced against buckling, a strong and efficient draft gear as a substitute for the elasticity of the wood, and a ratio of 0.04 for stress to end force, the calculations to include consideration of lever arm of force below neutral axis of the center sills. For lighter service a steel car with center sill area of 32 sq. in. and a ratio of 0.05 for stress to end force may be considered as a substitute for a wooden car with four 4-in. by 8-in. sills bunched near the center of the car. The use of steel permits a distribution of material to better advantage than is possible with wood. The box girder center construction is continually gaining in popularity, the strong vertical members at car ends, to prevent one car overriding and penetrating the superstructure of another car, are now considered a necessity, and a superstructure, including roof sufficiently strong to bear the car when turned upside down without collapsing, is very desirable.

5 To avoid making this paper too long other interesting problems will be omitted, but the truck problem deserves brief consideration. There are four-wheel and six-wheel trucks. They have 4¼-in. by 8-in., 5-in. by 9-in., 5½-in. by 9-in. and 5½-in. by 10-in. journals.

16 The impression that cars with six-wheel trucks necessarily have better riding qualities than those with four-wheel trucks has proved to be incorrect. The substitution of four-wheel trucks for six-wheel trucks saves about 18,000 lb. per car. Increased journal bearing surface obtained by an increase of diameter of journal only is of little or no benefit in preventing hot boxes, because the periphery velocity increases in the ratio of the diameters. The weight per journal should not exceed 1500

lb. per in. length. A long spring base, low-lying center plate, and anchoring the dead levers to the car body instead of to the truck frame promote smooth action and easy riding at all times. The equalizing springs should, therefore, be placed as near to the journal boxes as possible, or directly over the boxes, and the bolster springs should be on or near the center line of truck sides. If the dead levers of the truck brake are anchored to the car body, the truck frames have no tendency to tip up when the brakes are applied, and the jarring effect is entirely eliminated. A special axle with 5½-in. by 11-in. journal for passenger cars would be of material benefit, would permit using four-wheel trucks under all coaches and 60-ft. baggage cars, and longer cars with six-wheel trucks would have sufficient margin for the excessive loads sometimes encountered and the danger of hot boxes would be avoided.

UNDERFRAMES FOR STEEL PASSENGER CARS

By John McE. Ames,[1] New York

Non-Member

This paper will be confined to underframes of steel passenger cars for through service, or those at least 70 ft. long, and will not attempt to discuss those of suburban or individual service, whose underframes are not subjected to the same severe service strains.

2 The underframe is called upon to perform several functions. Not only must it sustain the weight of the superstructure and load, but withstand impact, oscillation and pulling strains without distortion. Were it not for these conditions the underframe might be considered as a bridge resting upon the center plates and side bearings as piers. Were we to design to meet only the carrying requirements the problem would not be difficult, but the design must also be commercial, not over heavy and in addition sufficiently strong to resist impact; commercial in that plates and shapes employed are such as may readily be secured from the steel mills, and not so heavy as to bring undue work upon either the hauling locomotive, rails, frogs, bridges, etc.

3 The natural division of such designs is:

a Underframes designed to carry equally on all sills

b Underframes designed to carry on center sills only

c Underframes designed to carry on sides only

c Underframes designed to carry on sides and center sills

4 Each of these types has its partisans and each type is in successful operation today. The first is the type used abroad almost universally and at home for repairs under wooden cars, the bodies of which are too good to destroy but need better un-

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

derframing. With most of the foreign cars the body rests upon and is bolted to the underframe from which it may readily be removed. The buffing and draft conditions differ from ours in that the buff is taken through the side sills by the use of separate side buffers, and the draft through the center sills thus permitting a distribution of metal in each sill member that may produce uniform stress.

5 An example of the first type designed for a wooden superstructure, consists of four deep sills of what is known as the "fish-belly" type (Fig. 1). These center sills are composed of 5/16-in. plates, 30 in. deep at the center with 3 in. by 3 in. by ⅜ in.

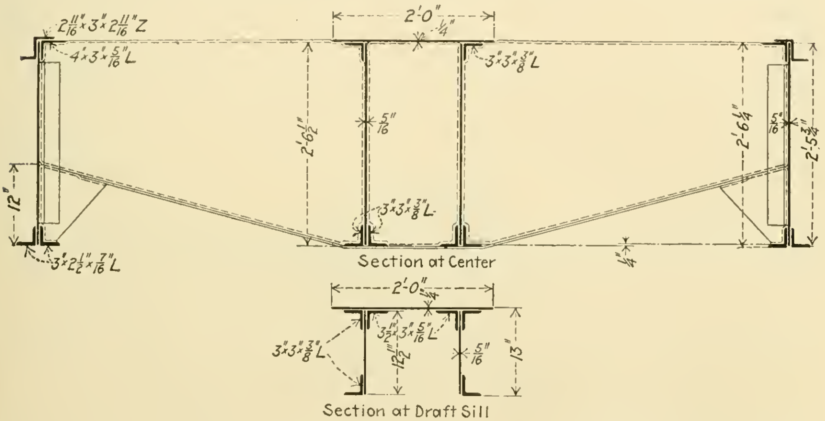

Fig. 1 Type *a*: Weight of Car carried equally on Center and Side Sills

angles riveted along the top and bottom edges; the plates reduced to a depth of 12¾ in. over the bolster. The center sills have a square inch section of 37 at the center, just as the side sills, and 26 at the draw gear. One disadvantage in these long plate sills is that when punching the line of holes along the edges the plate becomes distorted and wavy. It is then difficult to rivet the angles in place and obtain their full value. Again, in case of accident and the dropping of the underframe upon the roadway, the bottom angles are bent or broken, making a difficult repair operation.

6 In general the deep side sill has been discarded because of the difficulty of inspection beneath the car. The deep center sill is much in vogue at present because it looks strong, but on a car with deep center sills inspection must be made of the parts attached to the underframe from one side of the car at a time,

and the introduction of axle light equipment becomes difficult on account of the interference with the deep sills. Again, to sustain its own weight without deflection on a 60 ft. span, too much weight of metal is required to make such a sill economical.

7 Of the second type, that is, with the whole weight to be carried on the center sills, a common form (Fig. 2) has center sills of two special 18-in. channels with ½-in. cover plates top and bottom, all sections extending full length of the car in one piece. The box girder so formed has a square inch section of 50, and the superstructure load is transferred to these sills by means of

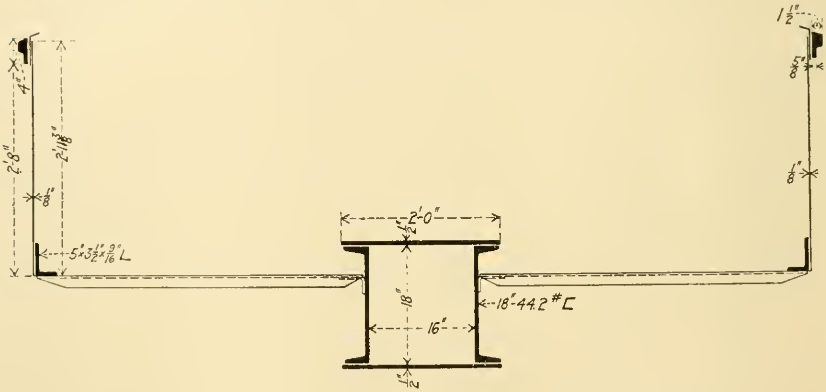

Fig. 2 Type *b*: Whole Weight Carried on Center Sills

four cross bearers, two of which take the place of the body end sills in other designs. There are no side sills as such, the angles here shown simply forming the attachment for the superstructure. The parts are usually assembled with the bottom of the sills upward and allowed to deflect. The girder is then reversed and the camber straightens out by the weight of the metal. The sills are the same depth and section throughout their entire length and with this construction a truck of special design must be used, the center plate of which must be nearer the rail than usual. The weight of the body rests upon the side bearings as well as the center plate. About 20 sq. in. of metal in the sides is available to help sustain the load. The service given by this underframe has been excellent.

8 The third type, with all the weight carried by the car sides has the center sills used only for buffing and pulling. An

example shown in Fig. 3 has two I-beams running full length of the car in one piece, with a square inch sectional area of 23. They are held up by the three cross bearers which pass under and are attached to them. There are no side sills, the carrying members being the sides of the car. These members are composed of ⅛-in. plates, about 36 in. deep, stiffened vertically by the window posts and having a 6 in. by 6 in. by ⅝ in. angle at the bottom and an equal square inch section of metal at the belt rail, the two girders having a square inch section of 48 in all. With this construction a substantial body bolster is essential, as the load must be carried at the bolster extremi-

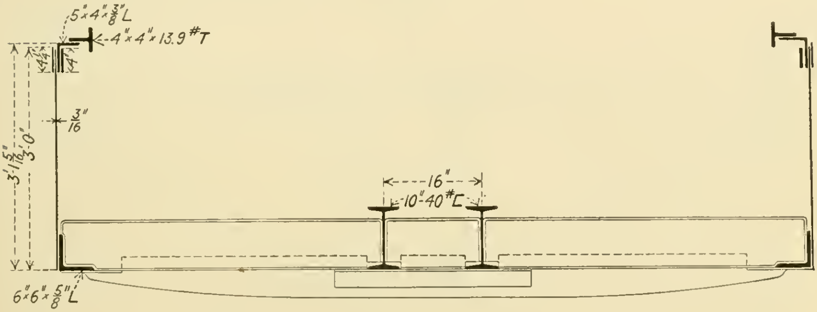

FIG. 3 TYPE *c*: WEIGHT CARRIED BY CAR SIDES, CENTER SILLS USED ONLY FOR BUFFING AND PULLING

ties. Usually a cast-steel structure, built into the underframe and securely riveted to it, is used, the metal may thus be economically distributed. With an underframe of this type there is no trouble due to difficulty of inspection or interference with attachment for axle light or other equipment under the car.

9 The fourth type (Fig. 4) is a combination of types *b* and *c*. Here deep center sills are used, having a square inch section of, say 40 at the center and 39 in cast steel at the draw gear. The side girders have a square inch section of 21 in the two. Most underframes of this type now in service are built with cast-steel end portions which include in one casting the body bolster, platform, side and center sills extending as far back of the bolster as may be necessary to secure a substantial connection to the center sills proper. This center member we do not consider as properly constructed for the reason that the section is unbalanced, an excess of metal being used on the top. Heavier angles or a

cover plate should be used on the bottom, which would add about 10 sq. in. or more of metal.

10 The four types illustrated are of underframes actually in service. A comparison of cross-sections discloses the fact that no matter from what angle the designer has approached the problem, approximately the same square inch cross-section has resulted. If, therefore, any one type has an advantage in weight over the

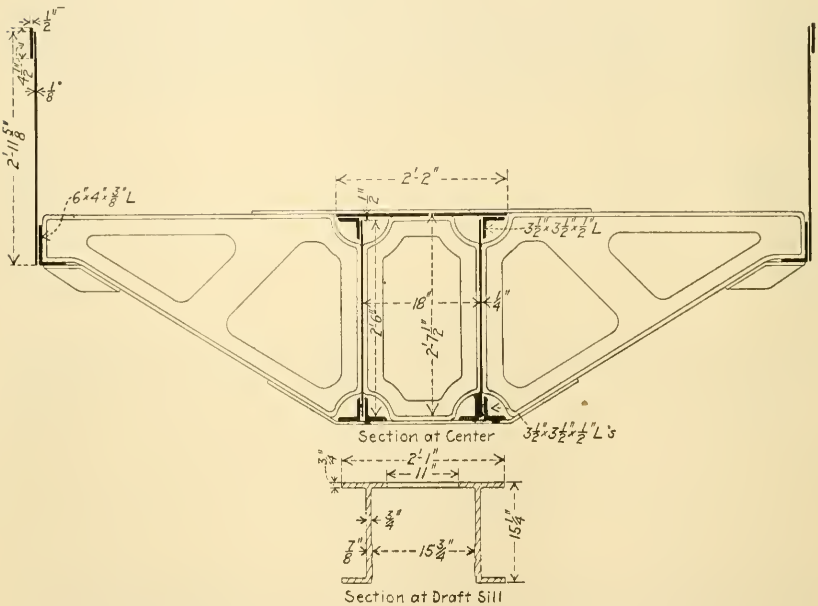

Fig. 4 Type *d*: Weight Carried both by Center Sills and Car Sides

others, it must be attributed to difference in the cross members of the underframe.

11 These four prevalent types have been recognized by the United States Government. The specifications of the Postoffice Department for the construction of steel postal cars provide as follows:

a Heavy center sill construction, the center sills acting as the main carrying member.

b Side-carrying construction, the sides of the car acting as the main carrying members, having their support at the bolsters.

c Underframe construction, in which the load is carried by all the longitudinal members of the lower frame. The superstructure shall be of steel.

d Combination construction in which the side frames carry a part of the load, transfering it to the center sills at points remote from the center plate for the purpose of utilizing uniform center sill area.

12 While several of these types have been in service for a number of years the required time has not passed in which to develop structural defects due to unseen causes, such as fatigue of metal, crystallization, etc. If such defects exist they should make themselves known during the next three or four years, if freight construction is any criterion.

ROOF STRUCTURE FOR STEEL CARS

By C. A. Seley,[1] Chicago, Ill.

Non-Member

Roofs for steel passenger equipment cars are of two classes, the clearstory type with minor variations and the oval type. As regards contour and general appearance, they are the same as the long established standards for wooden cars, but varied as to constructive detail, due to materials employed.

2 The advent of the steel car has rather encouraged the use of the oval or round roof, as it is often called, particularly for cars used for baggage, express, and postal purposes. It is cheaper to build and maintain and fulfills requirements for such cars. For passenger cars the clearstory type prevails very generally, as it assists in lighting and ventilation and in decorative effect.

3 The framing for oval roofs consists of carlines, each a single member, bent to the shape of the arch and extending from plate to plate. There are no through longitudinal members and the roof sheets are riveted to the carlines.

4 Framing of clearstory roofs is of two general classes, one employing carlines of one piece extending from plate to plate and carrying the longitudinal upper deck sills and plates, and the other class an extension of the side framing posts as far as the upper deck sill. To these extensions are attached a member which comprises deck posts and upper deck carlines. It is difficult to approximate the strength of the more direct lines of the oval roof in the design of the clearstory roof, and all riveted connections must be thoroughly considered. The deck sills and plates are through members, act as end stiffeners, and add to the longitudinal strength.

5 The shape of the carlines of either type of roof should be such as to facilitate fastening of roof and of the inner ceiling or finish, and between these there should be a generous amount

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of insulating material to intercept the heat of summer and the cold of winter.

6 The committee of engineers who framed the specification for full postal car construction, which was approved by the Post-office Department in March 1912, contains the following paragraphs in regard to the roofs of such cars and is probably as authoritative a statement as there is available. The strength of roofs of some cars that have been rolled over in accidents has been checked against the formula used, and it has been found ample to afford support against serious roof distortion in such cases.

7 The postal specification reads as follows:

ROOF

"General

The roof may be of either the clear-story or turtle-back type, depending on the standard contour of the railroad for whose service the cars are built. In the clear-story type, the deck plates shall be in the form of a continuous plate girder, extending from upper-deck eaves to deck sill, and either built up of pressed or rolled shapes or pressed in one piece from steel plates. The car lines may be either rolled or pressed steel shapes, extending in one length across car from side plate to side plate, or may extend only across upper deck. In the latter case the lower deck carlines may be formed by cantilever extensions of the side posts or by independent members of pressed or rolled shapes. In the turtle-back type, the carlines may be of either pressed or rolled shapes, extending in one length across car between side plate and side plate, or may consist of cantilever extensions of the posts.

"Carlines

The projected area of the portion of roof in square feet, supported by carlines, divided by the sum of the section moduli of the carlines, must not be more than 100.

"Roof Sheets

Roof sheets, if of steel or iron, shall be of a minimum thickness of 0.05 inches, and either riveted or welded at their edges."

8 The design of the roof is also subject to the general paragraphs on stresses and details of the postal car specification.

9 There are several bills in Congress having in view the substitution of steel passenger equipment on railroads for present wooden cars. Should any of these become law, specifications for construction will be necessary, and, as the postal car specification has been approved and adopted as standard by the Government, no doubt this specification will be used as a basis in determining the requirements for other steel passenger equipment cars, not only for the roofs, but for the other features of construction.

SUSPENSION OF STEEL CARS

By E. W. Summers,[1] Pittsburgh, Pa.

Non-Member

If we could operate steel cars over rails having no kinks, curves or irregularities in their alignment, in other words, over an absolutely straight track, there would be little need of springs or other devices for flexible support.

2 Unfortunately the roadways we have to contend with cannot be made or maintained in true alignment. Frost and water make constant changes in the track support. Lateral curvature requires super-elevation of the outer rail. In passing from a tangent to a curve, or vice versa, the tracks under one truck are in wind with those under the other one, sometimes as much as 4 or 5 in. depending upon the degree of curvature and the length of the car.

3 Steel car bodies of the enclosed type, such as box cars, mail, baggage, or passenger coaches, are of rigid construction and have high torsional resistance. A three-legged stool on an irregular floor surface will stand upon all of its legs while one having four legs may carry all of its load upon two diagonal supports.

4 The use of truck springs helps the illusion that we are distributing the car body load on all of the wheels. The uneven deflection of the springs indicates directly the increased load of one spring over the other. When the track surface is warped more than the total spring travel, the whole load is carried at two diagonal corners, tending to twist the car body. This twisting tendency is constantly changing, first in one direction and then in the other, as the super-elevated rail changes from one side of the track to the other. The effect upon wooden passenger cars is to work the joints loose and cause them to screech and grind like the spokes of a wooden wagon wheel in hot dry weather.

[1] President, Summers Steel Car Company.

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5 The side bearings of steel sleeping cars pop like sledge hammer blows when the car is taking or leaving a curve. The slight twist in the track surface throwing excessive load upon two diagonal corners of the car causes the bearings to grip and adhere to each other coincident with the slewing of the truck. When the twisting of the truck exceeds the play in the parts around the truck bolster the side bearings let loose and jump with the resulting hammer blows. More efficient roller side bearings may prevent the gripping and jumping, but the uneven load is still present. The twisting effect upon the car body is not removed.

6 Failure in roofs of wooden box cars and the resulting damage to merchandise in transit is due to this constant twist. Roof designers have attempted to remedy this by making the roof flexible and with slip joints. To be consistent they should go further and make the whole car of india rubber. A practical construction for the enclosed type of steel car bodies must and always will be rigid and of high torsional resistance.

7 The necessity for flexibility between the car body and the trucks, and for an even distribution of the load upon all of the wheels seems not to be fully appreciated as yet, but with each succeeding year wrecks due to broken rails, wheels and truck structure will drive this home. Suspension of steel cars, as has been developed by the writer in the past three years, does permit of a more even distribution of the load upon the wheels than with center-bearing trucks.

8 Fig. 1 is an illustration of a cross-section through an engine tender at the center of one of the trucks. It illustrates the method of suspension referred to and is applicable to any kind of car.

9 The inclined hangers *a*, the cradle *b*, and the side rockers *c* are shown heavily shaded. There are two inclined hangers at each side of each truck. A heavy rectangular bar extends through the lower ends of the hangers *a*. A cast-steel bracket, which is part of the car underframe, rests upon each end of the rectangular bar. The upper ends of inclined hangers *a* are supported upon the outer end of the cradle which rests upon the segmental rocker *c* and transmits the car body load directly into the truck side frame. The lower ends of hangers *a* are maintained a fixed distance apart transversely of the car, by reason of the brackets *d* being a fixed part of the car underframe. Their upper ends are held at a fixed transverse distance by their connection with

the cradle *b*. Both the upper and lower ends of bars *a* are pivotally connected with rolling contact.

10 With one end of a car on level track and the other end having one rail at a higher elevation, the tendency will be for

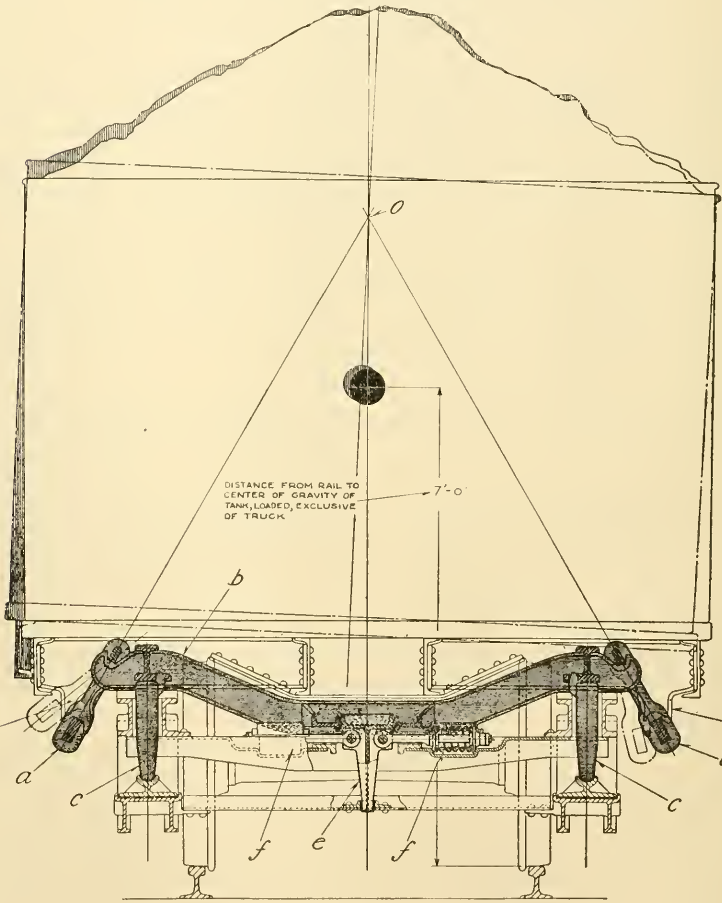

FIG. 1 CROSS-SECTION OF ENGINE TENDER AT CENTER OF ONE OF TRUCKS

the high rail to carry all of the load at that end of the car, or to have the car support taken at two of its diagonal corners.

11 With *inclined hanger suspension* the car will swing sideways, the hangers at the high rail swinging inward and down-

ward, while the ones at the other end of the cradle swing outward and upward, picking up the load at the low rail and maintaining its distribution on all of the wheels much the same as if suspended by two bars from a point *O* at the intersection of the center line of the inclined hangers extended. The load or rigid car body will find its own position vertically under this common point of support *O*, each of the extended suspension bars taking its share of the load.

12 The slight warping of the track surface, which causes all of the load to be carried on half of the wheels at two diagonal corners of a rigid car body with the ordinary center-bearing truck, is corrected by the short inclined suspension bars *a*, practically the same as if the suspension was from point *O*.

13 It is the inclination of these bars that makes vertical adjustment possible, one bar swinging inward and downward, the other swinging outward and upward at one end of the car, the bars at the other end swinging in the opposite direction, the car body finding its position much the same as a boat does in water.

14 Imagine the bars *a* at one end of a car swung to the left, as shown in the unshaded dotted position, and at the other end swung to the right an equal amount: this makes correction for a warped track surface of about 8 in. in the length of a car. Or, imagine the hangers *a* swung to the left at both ends of the car, as shown in the dotted position: this is the inclination the car body will assume in rounding a sharp curve at high velocity, the top of the car leaning inward and the bottom swinging outward, the position assumed by a bicycle rider in rounding a curve.

15 The cradle *b* is pivoted about a vertical axis on the king pin *e* and can also have movement transversely of the car, this movement being limited by the action of springs *f*. On account of the inertia of the car body and its load, the cradle moves transversely of the car, rotating the hangers about their lower ends when rough track is encountered at high speed. Without this cradle movement, the inclined hangers are impracticable; with it, the car body movement is without jar or jerk and we have perfect adjustment for all track conditions.

16 The car body is carried at each side almost directly under its rigid side girders, which by position have great depth and can carry the load with the least deflection. Floor beams may be made continuous from side to side of the car. The necessary buffing and tugging column may be disposed with its web in a

horizontal position under the transverse beams, greatly simplifying the car framing.

17 With the advent of steel construction for enclosed cars a rigid structure came into use, one that cannot be handled over rough track as we have been handling the spongy wooden structure. There may be much hewing and chopping into old methods before the necessary compromise is made between the rigid car body and the changeable track surface, but why not do it all at once, and stop fooling with dynamite?

SIX-WHEEL TRUCKS FOR PASSENGER CARS

By John A. Pilcher, Roanoke, Va.

Member of the Society

Consideration of the subject of trucks for steel passenger cars is practically a consideration of trucks for any passenger car, the primary thought being that steel passenger cars should have steel trucks to prevent the possibility of fire, and also because of their great weight, metal is the most suitable material for strength and durability that can be used in the limited space available for the truck. The fire damage from a wooden frame truck could not be serious on a steel car, and there are wooden cars equally as heavy as the general run of steel cars; the writer having one in mind in the construction of which the sills were plated with 8-in. channels, weighing 172,700 lb. A few steel cars weigh as much as this, but we have no record of any weighing more. However, for steel passenger cars we will consider only the all-steel truck.

2 Practice of the past brings to our attention the pedestal type of passenger truck construction both for four-wheel and six-wheel trucks, the general characteristics of both being identical. The six-wheel truck with the same size axle is, of course, capable of greater load and also of transmitting to the car the track irregularities to a less extent, because the results of the irregularities are modified by the system of equalization. In the six-wheel truck the location of the equalizer springs is fixed at a definite point between the wheels.

3 While the details of these two trucks differ slightly, their functions are practically identical. Both trucks have been used for a considerable length of time, but the four-wheel truck was evidently developed first and its necessary functions, determined by experience, were later incorporated in the design of the six-wheel truck, which was probably first brought about by the increased loads.

4 Except for the especially constructed truck used by the

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Pennsylvania Railroad and one other, which we understand has been designed, these are the only regular types of trucks available.

5 *Wheels.* For passenger service, the wheels have been practically narrowed down to steel tired wheels and wrought-steel wheels. The steel tired wheels have been of many forms of centers and fastenings; the latest recommended practice of the Master Car Builders Association is that the tire be shrunk on and bolted. The recent development of the solid wrought-steel wheel has made available for passenger car service a wheel equally as safe and durable as the steel tired wheel at a very much reduced cost. The Master Car Builders' recommendations recognize both the 36-in. and 38-in. size in this wheel for passenger service, the 36-in., however, being the most generally used. These wheels, if carefully turned, should give as satisfactory service as any wheels available.

6 *Axles.* The standards of the Master Car Builders Association gives the choice of selection of four sizes of axles:

Size of Journal	Axle Load, Lb.
3¾ in. x 7 in.	15,000
4¼ " x 8 "	22,000
5 " x 9 "	31,000
5½ " x 10 "	38,000

7 They also offer an axle as recommended practice with 6 in. by 11 in. journals for 50,000-lb. axle load. These loads, however, are for freight service; for passenger service we would recommend the use of from 60 per cent to 75 per cent of the loads used in freight service, based on the light weight of the car, and limiting the load to about 90 per cent of that in freight service, considering the weight of both car and lading. The lighter rating is, of course, to be taken for cars such as baggage and express, since the increased weight on account of lading would be heavier, while the higher rating could be taken for coaches and similar cars where the increase of the lading would be light. Table 1 gives the sizes of axles, and relative light weights of cars on this basis.

8 The Postoffice Department has limited the maximum load per wheel for postal cars to 15,000 lb. when using 5½ in. by 9 in. journals, and to 18,000 lb. when using 5 in. by 10 in. journals, making a further limitation based upon 18,000 lb. as the maximum brake load for any one cast-iron brake shoe under emergency conditions of brake application. This limitation of wheel

loads, after deducting the weights of the wheels and axles, allows a pressure of 304 lb. per sq. in. projected area on the 5 in. by 9 in. journals, and 300 lb. per sq. in. projected area on the $5\frac{1}{2}$ in. by 10 in. journals, also a pressure of 1522 lb. per lineal in. on the 5 in. by 9 in. journals, and 1665 lb. per lineal in. on the $5\frac{1}{2}$ in. by 10 in. journals, and from the experience that some roads have had these seem to be just as high as should be allowed.

TABLE 1 SIZE OF AXLES AND WEIGHT OF LIGHT CARS

Axles, In.	Four-Wheel Trucks, Lb.	Six-Wheel Trucks, Lb.
$3\frac{3}{4}$ x 7	40,000 to 52,000	60,000 to 78,000
$4\frac{1}{4}$ x 8	52,000 to 72,000	78,000 to 108,000
5 x 9	72,000 to 100,000	108,000 to 150,000
$5\frac{1}{2}$ x 10	100,000 to 120,000	150,000 to 180,000

9 *Boxes and Contained Parts.* The Master Car Builders Association has provided standard passenger boxes for axles with $3\frac{3}{4}$ in. by 7 in., $4\frac{1}{4}$ in. by 8 in., and 5 in. by 9 in. journals. For the $5\frac{1}{2}$ in. by 10 in. journal, which is often in use, they have not yet established recommended practices, but the previous designs are having their influence on the shape of the box for this journal.

10 *Pedestals.* Cast-iron pedestals seem to be usually the accepted material, and the Master Car Builders Association has also provided standards to suit the boxes.

11 *Equalizer Springs.* These are four in number on both the four-wheel and six-wheel trucks, and while necessarily provided with a limited amount of deflection, they relieve the heavy truck frames of shock, and on six-wheel trucks provide the points of support for the proper equalization.

12 *Wheel Pieces or Side Frames with Transoms or Cross Ties.* These constitute the truck frame to hold the other parts in their relative position, and at the same time transfer the load from the bolster hangers to the equalizer springs. Being structures supported at four points, they necessarily have to be supported on springs to prevent excessive stresses due to any variations in the height of these four points. As an illustration, when the truck on a tangent is approaching a curve the rise of the

outer rail is about 1 in. in 50 ft. This will raise one of these four points above the plane passed through the other three, and, while the difference is small in the short length of the truck, the irregularity has to be taken up by the springs, otherwise the truck frame would be similar to a four-legged table with one high leg.

13 When we consider the case of a derailment where one wheel of the truck, whether four-wheel or six-wheel, falls into a deep hole, or drops from a high rail, we find this condition exaggerated to such an extent that the whole load will be supported on two points. Then unless the structure is sufficiently flexible to follow, it will necessarily have to be strong enough to resist this abnormal load.

14 The calculation of the stresses under such uncertain conditions of loading is certainly a very complex problem. It is a pertinent question whether or not the designers should undertake to care for such an abnormal condition.

15 *Bolster Hangers.* The lateral movement of the bolster, one of the very necessary features of a passenger truck, is usually accomplished by the use of swinging hangers. This movement should be limited to from 1½ in. to 1¾ in. each side of the center, and in placing this limit arrangement should be made so that the stop will not be abrupt. This is ordinarily accomplished by the use of short hangers, or when long hangers are used by the addition of lateral motion springs, either of which offers an increasing resistance. Rollers on cylindrical or curved plains can produce the identical movement made by the short hangers.

16 *Bolster.* On the four-wheel truck the bolster is a simple beam, but on the six-wheel truck we have a more complex structure resting on four points of support. This condition brings up the same complex problem referred to in connection with the truck frame supported on four points, except that it rests on much more flexible springs than does the truck frame. These springs can hardly be expected to take up all of the variations in elevation that will likely be met with in case of a partial derailment. The same question as to whether or not the designer should allow for such abnormal conditions is again raised.

17 *Center Plate.* The usually accepted center plate for passenger cars is of the spherical pattern, allowing more perfect adjustment, and more even distribution of weights than can be obtained from the flat bottom center plate, but making necessary

close and accurate adjustment of the side bearings to prevent the rocking movement between the car body bolster and the truck bolster.

18 The frictionless center plate would of course be very desirable, but conical rollers and balls of sufficient number, of the size that can be put in the available space, seem not to have been as successful as could be wished. The ingenious designer is still at work on this particular problem.

19 *Side Bearings.* Side bearings must be made so that they can be readily kept adjusted to reduce to a minimum the rocking movement between the car body bolster and the truck bolster, and in this way confine the oscillation of the car to the variation in the deflection of the springs on either side.

20 The relative location of the side bearings, each side of the center, is a question often discussed. In passenger cars the practise generally is to place them at as great a distance from the center as practical. This in our judgment is correct, and of particular advantage in the case of frictionless or roller side bearings.

21 Where the side bearings are in actual contact and the bolsters are rigid, the oscillation of the car is controlled entirely by the difference in deflection of the springs on either side, so that if the side bearing is set out sufficiently far to prevent the car body upsetting on the truck, it serves its purpose in preventing car oscillation as well there as at any other location.

22 For the same type of side bearing, it offers just as much, but no more, resistance to turning than if located far from the center, because as the lever arm is increased the pressure is reduced in like proportion.

23 When the car on a tangent is approaching a curve, the rise of the track on the outer rail tends to bring a pressure on the side bearing of the leading truck, next the outside of the curve, and on the side bearing of the trailing truck toward the inside of the curve. Where the side bearings are in contact this variation in elevation has to be taken care of by the deflection of the springs which have to deflect the same amount whether the load is exerted on the bolster, at a point near the center, or far away from the center. If the load comes far from the center it takes much less pressure to influence the deflection of the springs. This would be to the decided advantage of the side bearings, particularly in the case of the frictionless side bearing,

in preventing wear and would also, to a more limited extent, be of advantage to the ordinary flat side bearing.

24 *Brakes.* On passenger cars, the pressure on the brake shoes approximates the loads on the wheels. Particularly is this the case of coaches where the lading is only a small proportion of the total weight. In some braking arrangements the brake shoe load is even greater under certain conditions than the wheel load; therefore the lighter the wheel loads the better for the brakes. This is a decided argument in favor of the six-wheel trucks for heavy cars, and an argument against the use of four-wheel trucks under heavy passenger cars, even though the weights can be readily sustained by the use of sufficiently large axles.

25 The application of the brakes to the six-wheel trucks in such a manner as to allow for the adjustment of worn shoes and worn wheels is a very difficult task on account of the limited space available. It is almost impossible to accomplish this task with the use of wheels less than 36 in. in diameter.

26 *Six-Wheel Trucks.* Since steel cars are of recent construction, and recent conditions have generally called for large cars, the weight is almost always great. The six-wheel, all-metal truck has the following advantages which make for its selection over other types:

a It is non-inflammable.

b It provides a strong material to resist the heavy loads, and occupies only a limited space.

c It provides a durable material.

d It reduces the axle loads, and the unit load on the bearings, lessening the liability to hot boxes, reducing the pressure on the brake shoes, lessening the tendency to heat the wheels and shoes, adding to the life of the brake shoes, and reducing the frequency between renewals and adjustments.

e It spreads the heavier loads over a greater area of structures, and brings more points of contact with the rail, reducing the influence of track irregularities on the riding of the car, and in cases of very heavy cars, where the unit pressure between wheel and rail might approximate the elastic limit, reduces the tendency to shell the wheel and roll out the rail, adding to the life of both.

27 It has been estimated that for a passenger car making 50,000 miles per year, the cost for hauling the car is 5 cents per lb. per year. If the six-wheel trucks weigh 14,000 lb. per car more than the four-wheel trucks necessary to carry the same car, it means the hauling of 14,000 lb. additional at a cost of $700 per year, which brings up a question for vital consideration.

28 While the wheels, brasses, and brake shoes, and other such removable parts may individually have a longer life, there are also more of them in service during the period. Careful comparison would have to be made to determine which has the advantage at this point.

29 *Four-Wheel Trucks.* The four-wheel, all-metal truck is also available in connection with steel cars, and has the advantage of reduced first cost, reduced weight, smaller number of parts to maintain, and if the car is sufficiently light for the unit stress between the rail and wheel to be kept down to a point well below the elastic limit of the material, they should be given serious consideration. The only drawback under these conditions is the possibility of its reduced riding qualities. Its decided advantage in reducing the weight of the train should help to make it a favorite because of the corresponding reduction in the cost of transportation.

30 *Cast-Steel vs. Riveted Wrought-Steel Frames.* The introduction of heavy passenger equipment is rapidly doing away with both the four-wheel and six-wheel wooden frame trucks. The reduced cost of maintenance amply justifies this change if our information is correct. Cast-steel one-piece frames, and riveted wrought-steel frames of various cross-sections have been worked out and are now in use; both are reported as giving satisfactory service, but figures showing the exact relative cost of maintenance are not available.

31 The cast-steel one-piece frame has become a great favorite even in the face of the high unit cost of these particular castings. The adaptability of the castings to the various changes of form and section necessary on account of the limited available space has no doubt had much influence. The attractiveness of the one-piece structure, eliminating all joints, and furnishing a frame ready set up, is another strong argument in its favor. The manufacturers having control of this cast-steel truck frame have evidently been successful in reducing to a minimum the concealed flaws often met with in steel castings. This, no doubt, has added largely to its popularity.

32 While the absence of riveted joints and the consequent doubling of material at the joints, helps to keep down the weight, the fact that the working fiber stress of cast steel is taken low, and the sections at many points have to be made larger than is necessary on account of foundry limitation, the weight of the frame as a whole is great. This added to the large unit cost for special steel castings makes the user pay well for the advantages gained.

33 The riveted wrought-steel frame seems to have been held back in its development by the success of its rival in cast steel. Many users have shown conservatism in making use of the good thing already considered acceptable, hesitating to try out the different construction with the hope of lower first cost, with less weight, and equally good service.

34 Wrought steel at a very moderate unit cost has the advantage of being a very reliable material which can be worked to a relatively high fiber stress. The cost of fabrication, when the work is done in any large quantity, when added to the cost of material, will still leave a large margin in its favor. Is it possible that the lack of an especially interested advocate has prevented its virtues from becoming prominent, and delayed the experience needed to prove, in actual service, its worth?

35 We find that practically all of the prominent car builders have already worked up designs for wrought-steel trucks, and are ready to construct them if the purchaser so desires, but they do not seem inclined to push them, as they evidently offer no special inducement to their own advantage. Only a few have been built and placed under cars by them, and in some cases none, but from what I have been able to find out they have confidence in them.

36 I find several railroad companies building and using both four and six-wheel trucks, of the usual type of construction, with riveted wrought-steel frames, and from all reports they are giving satisfaction.

37 Another prominent railroad is using both four and six-wheel trucks, of a form of construction differing from the ordinary type, built of riveted wrought steel. As a large number of these are in daily evidence, and are constantly being built by them, they must be proving the worth of the riveted wrought-steel construction, as well as that of the special type of construction.

38 Experience of several years and careful comparison of the cost of maintenance will be needed to say whether the one-piece cast-steel frame, or the riveted wrought-steel frame truck will be the most advantageous, when both the first cost and weight are considered along with the cost of maintenance.

39 Variety of choice offers an opportunity for discussion. In the hope of bringing out this discussion we advocate for steel passenger cars:

a Six-wheel truck.

b The riveted wrought steel frame.

c The use of the Master Car Builders standard axles, boxes and parts, and pedestals.

d 36-in. wrought-steel wheels.

STEEL INTERIOR FINISH FOR STEEL PASSENGER CARS

By Felix Koch,[1] McKees Rocks, Pa.

Non-Member

Every one who has followed the progress in steel passenger car construction during the last ten years, which is about the age of the oldest steel passenger car, has noticed that very little, if any steel was used in the interior finish until within the last four or five years.

2 The first attempt to use steel in passenger cars resulted in steel underframes with wood superstructure. The next development provided steel underframe and steel superstructure, but with wooden roof and wood interior finish. Further developments eliminated the wooden roof and the final efforts produced an all steel car. Considering that this development was made during a period of four years, the results obtained are, to say the least, highly gratifying.

3 The earlier designs of steel cars with steel interior finish are sometimes called all steel cars, leaving the impression that they are fire-proof in every respect, but this is not correct because too much wood was used in the form of wood furrings to enable the application of the steel finish with wood screws. These furrings were, of course, not exposed to view, but they nevertheless placed the cars outside of the classification "all steel cars." The idea that it was necessary to use wood furrings in order to make it possible to apply steel finish, or in other words, that wood screws had to be used, machine screws not being considered practicable, accounts to some extent for the tardiness in the introduction of steel in the interior finish.

4 The earlier specifications and designs for steel passenger cars made the use of machine screws for applying the interior finish prohibitive and impossible, which, of course, made it nec-

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essary to employ other means such as bolts or wood screws. Bolts for this purpose must have heads of special design to allow their insertion through slotted holes, etc., and to prevent them from falling through during the application of the nuts. The nuts, being exposed, are objectionable as they give an unsightly appearance, even if special cap nuts are used in place of the ordinary nuts, besides there are many places on a car at which it is impracticable to apply bolts. Therefore, to avoid machine screws and bolts the space between the outside sheets and the interior finish were filled with wood furring to allow for the use of wood screws. The objections to machine screws, caused by the belief that they would work loose in a short time, has, however, disappeared from experience gained through actual service as it has been shown that if set in white lead and properly applied they are entirely reliable.

5 There has always been and there still is a great difference of opinion as to how far it is advisable to substitute metal for wood in passenger car construction. The use of a small amount of wood in the interior finish, as for instance window sash moldings, seat arm rests, window capping, etc., should not be objectionable as it has certain advantages over steel which are desirable, but wood is used for such details to a considerable extent, and hundreds of cars are now in service in which the small amount of wood used in the interior finish cannot be detected except by an expert and such cars are to all intents and purposes fireproof cars, but the aim of many designers has been to eliminate the wood wherever possible on account of the many advantages possessed by steel, among which may be mentioned:

a Steel finish means non-combustion in case of fire.

b Steel prevents splintering in case of wreck.

c Steel finish can be easily removed should it become necessary to repaint the car at the inside surface of steel sheets, as the life of the steel car, to a certain extent, depends on the condition of the paint.

d Steel finish makes it possible to increase the interior width of the car where outside width is limited. This has been found particularly valuable in designing subway, elevated or suburban steel passenger equipment cars.

e Steel finish will avoid trouble which may be experi-

enced due to different expansion of materials, steel against wood. This point need not be considered with steel and makes it unnecessary to provide for relief in all members of the finish running longitudinally, such as upper and lower deck sill moldings, etc. In fact, the steel finish has revolutionized to some degree the designs of wood finish in the wooden cars built since steel cars came in vogue. The cars of today are built on more sanitary lines, and fancy moldings, fretwork and carvings have disappeared without losing sight of giving the cars an artistic finish, avoiding thereby lodging and breeding places for all kinds of germs which the world is fighting against today.

f Steel finish will, by comparison, be cheaper every year for the reason that it becomes more difficult to obtain the right kind of lumber for interior finish, which, of course, means increase in price of wooden cars.

g It is continuously becoming more difficult to obtain men who have had sufficient experience in applying wood interior finish, whereas it does not take the same experienced men for applying steel finish. A man requires from three to four years' apprenticeship to become an expert able to apply wood finish to a car, whereas an average intelligent man who is familiar with tools is able to become an expert in finishing cars with steel finish in from six to twelve months, and this fact of labor will have to be taken into account sooner or later.

h A more uniform color can be maintained on steel finish than on wood which comes in different shades, and it is very difficult and expensive to match perfectly all parts in one car with regard to shade without additional expense of glazing. Furthermore, the average life of paint applied to steel finish will be much greater than to wood finish for the reason that wood darkens with age. This, of course, influences the paint which is a disadvantage from the standpoint of illumination. Should it become necessary to repaint a car of wood finish, reworking of the finish by removal of the varnish and scraping is neces-

sary, whereas in the steel finish the scraping is eliminated and the removing of varnish is alone required to be able to repaint the car.

i Steel finish is of advantage from a building standpoint in the handling and working up of material to make ready for application. Steel details can be worked up to a large extent before they are applied to the cars, which make it possible to manufacture the interior finish in much less time by the use of more men, than it is possible to employ when applying a wood finish, as only a limited number of men have room to work at the same time in a car when the greater part of the fitting and cutting, etc., has to be done. This has facilitated the establishment of a number of manufacturing concerns who devote their efforts almost exclusively to producing steel interior finishes not only for passenger cars but also for buildings. In addition to these any manufacturing company equipped with the necessary machinery for the making of drawn moldings, breaker presses, and ordinary welding and spot welding machines, is able to handle this class of work for railroads or carbuilders, who may not have the necessary equipment to do the work in their own shops and prefer to buy the interior finish as they buy other specialities.

6 All of these advantages are almost exclusively confined to the use of steel or other metals, although a composite material of a wood pulp nature or similar material made fireproof and waterproof by different processes, if applied in a proper way and used for ceilings and below the window sills, is not objectionable, and it may be applied in practically the same manner as steel.

7 The advantages possessed by wood over metal as a non-conductor can be very much reduced by the use of proper insulating material correctly applied. The use of proper insulation is of course of great importance and manufacturers of that class of material as well as railroads and car builders are giving a great deal of attention to the subject, and the time does not seem to be far distant when steel cars with interior finish of wood will be as scarce as steel passenger cars were ten years ago.

8 A great deal more could be said on this subject, but it is hoped that what has been brought out will show that steel interior finish has certain advantages not possessed by other material commonly used in passenger cars and that the disadvantages are few and not insurmountable.

PAINTING OF STEEL PASSENGER CARS

By C. D. Young, Altoona, Pa.

Member of the Society

A fundamental reason for painting any surface of a passenger car is to protect it from the damaging effects of the air which is more or less loaded with gases and moisture. For example, oxygen is destructive of iron and steel and when sulphurous gases are present they are quickly oxidized into sulphuric acid which is very corrosive to unprotected metallic surfaces. It, therefore, becomes necessary to protect the surface by a covering, and paint forms a substantial and convenient means for accomplishing this. If properly made and applied, it is an impervious coating, affording the needed protection by forming a hard waterproof, rubber-like sheeting or film which has sufficient elasticity to conform itself to the contraction and expansion of the surfaces to which it is applied. In addition to protection the surfaces may be beautified and embellished by the proper selection of pigments so as to bring about the harmonizing and artistic effects desired.

WOODEN EQUIPMENT

2 The painting of wooden passenger-car equipment has been, in the main, successfully accomplished, the painting schedule for the outside is briefly as follows: Apply two coats of primer, putty and glaze, followed by three or four coats of surfacers, as found necessary, after which the surfaces are rubbed down smooth with emery and oil, when two coats of shade color are put on. The necessary striping and lettering follows, completing by three coats of finishing varnish, consuming in all about sixteen to eighteen days.

3 The finishing of the interior of wooden cars generally has been in the natural wood, consequently it is only necessary to prepare the surface for the varnishing. A representative sched-

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ule which is used is as follows: One coat of filler, in paste form, which is sandpapered down to a smooth finish. Add one coat of rubbing varnish and rub down with sandpaper, after which apply three coats of rubbing varnish, and complete the finish, cutting down the gloss by rubbing with pumice and oil to produce the most pleasing "flat finish."

4 This method of finishing the wooden surfaces of cars has been attained with good results, so that naturally when the change to steel passenger equipment came some six years ago, a desire to retain as much past practice as possible seemed desirable. It was realized, however, that the all important point in the painting of iron or steel surfaces was first to have the surfaces thoroughly cleaned and entirely rid of scale and rust, as this is as important as the painting itself. To accomplish this, sand-blasting, where possible, was resorted to, supplemented by the use of wire brushes and emery cloth in the more obscure places and the more uneven surfaces. The sand-blasting, however, was confined largely to the outside surfaces and the latter practices to the inside portion of the car.

5 Iron and steel, while not presenting to the eye the same porous condition as wood, is full of finely divided pores, and the same atmospheric influences which enter the pores of wood and cause it to decay are ever ready to attack the unpainted surfaces of iron and steel, in fact the metal surfaces more readily combine with the oxygen and moisture of the air, forming what is rust or oxide of iron. Therefore, immediately after the sand-blasting and cleaning of the surfaces should come the application of the first or primary coat, as this is the most important one, from the preservative standpoint.

6 In the selection of a suitable primer it seemed but natural for the painter to be guided by the experience gained in the painting of locomotive tenders, and to follow the initial coats with practically the same process as with wooden cars, and I believe that so far as the subsequent coats are concerned, this practice was generally carried out by the earlier painting of steel passenger equipment. It is thought that an error has been made in this general practice, as will be explained later.

STEEL EQUIPMENT

7 The schedule for painting steel passenger car trucks, underframes and superstructures is as follows:

8 *Trucks.* Before assembling, all surfaces on truck parts throughout, including all concealed surfaces, but not including wheels and axles, must be covered with one coat of suitable primer. After assembling, all surfaces (except wheels) exposed to view after the body of the car has been placed on trucks, must be covered with two coats of truck enamel.

9 *Underframes.* During the process of construction, all parts of the underframe, including concealed surfaces and surfaces where metal bears on metal, must be covered with two coats of good metal preservative of a non-inflammable nature. All accessible surfaces must be covered with a third coat of metal preservative.

10 *Superstructures.* Before assembling, all parts made of iron or steel, including the roof, must be covered with one coat of primer. A second coat of primer properly thinned with turpentine, or similar material, must be applied to all surfaces, including those which are concealed when the car is completed. Wherever possible, this second coat must be put on after the sheets are in place.

11 After assembling, the outside of side and end sheeting. including letter plate and deck plate, must be covered with one coat of surfacer, the rough and uneven places glazed with "surfacer composition," four coats of surfacer being added, rubbed down with linseed oil and emery cloth, two coats of desired color material added, followed by striping and lettering, then finished with three coats of finishing varnish. The outside of the roof must be finished with one coat of heavy protective paint, followed by one coat of a mixture composed by volume of three parts of mixed ground color and one part of the protective coating used. The top surface and edges of headlining should be painted with two coats of some preservative, or color paint.

12 The interior of cars should receive very careful attention in order to produce the desired finish. To illustrate fully the various steps and time taken to complete the painting, the following is given as outlining the progress of the work. This is attained with the use of surfacers, colors and varnishes containing a relatively large amount of artificial driers and varnish gums, in order to obtain the artistic finish desired for the interior.

HEADLINING

1st day Apply one coat and stipple after application.
2d day Stand for drying.

3d day	Apply one coat and stipple after application.
4th day	Stand for drying.
5th day	Apply one coat and stipple after application.

SIDES ABOVE WINDOW SILLS AND ENDS

1st day	Apply one coat or priming.
2d day	Stand for drying.
3d day	Apply one coat surfacer.
4th day	Necessary puttying and glazing.
5th day	Apply as many coats surfacer as are necessary to make a level surface.
6th day	Same as 5th day.
7th day	Rub down with emery and linseed oil.
8th day	Apply one coat of ground color.
9th day	Apply one coat of ground color.
10th day	Apply one coat of ground color.
11th day	Apply one coat and stipple after application.
12th day	Apply one coat rubbing varnish.
13th day	Stand for drying.
14th day	Apply one coat rubbing varnish.
15th day	Stand for drying.
16th day	Apply one coat rubbing varnish.
17th day	Stand for drying.
18th day	Rub with oil and pulverized pumice stone.

SIDES BELOW WINDOWS

1st day	Apply one coat or priming.
2d day	Stand for drying.
3d day	Apply one coat surfacer.
4th day	Necessary puttying and glazing.
5th day	Same as 6th day.
6th day	Apply as many coats surfacer as are necessary to make a level surface.
7th day	Rub down with emery and linseed oil.
8th day	Stand, awaiting bringing up other work.
9th day	Stand, awaiting bringing up other work.
10th day	Apply one coat bronze green.
11th day	Apply one coat bronze green.
12th day	Apply one coat of rubbing varnish.
13th day	Stand for drying.
14th day	Apply one coat of rubbing varnish.
15th day	Stand for drying.
16th day	Apply one coat of rubbing varnish.
17th day	Stand for drying.
18th day	Rub with oil and pulverized pumice stone.

13 Formulae and panels for the various shades should be furnished the painters for their guidance in obtaining the shade of any of the colors which are desired.

RESULTS OF AIR DRYING PAINTS ON STEEL

14 The artificial driers and gums used in hastening the time of drying and hardening of the various coats and permitting the necessary rubbing continue this action so that the paints and varnish increase in hardness and brittleness, rendering them susceptible to cracking and chipping, and the process of disintegration is aggravated by excessive expansion and contraction of the steel surfaces as compared with wood. The linear expansion of steel being more than twice that of wood would seem to indicate the use of more elastic coatings than formerly used for wooden cars.

15 This fact has been borne out in the service of the paint in a great many cases in an investigation which recently came under my observation. It was noticed that when some of the equipment had been in service about four months, the interiors of the cars were showing varnish cracks and checks. As time went on more cars gave evidence of this deterioration, the final outcome being that an investigation was made to see how serious the condition was. Some 400 cars were carefully examined, special attention being paid to choose cars built by various manufacturers, where different makes of surfacers and varnishes were employed. An endeavor was also made to determine whether the cracking of the painted surfaces was confined to the varnish coats or the surfacer coats, or both.

16 In order to classify the various conditions found, four readings of percentages were arbitrarily taken, the condition of a new car being taken at 100 per cent:

Per cent	Condition of Varnish and Surface
90 to 80	Good, no checking
80 to 70	Fair, slight checking
70 to 60	Medium, considerable checking
60 to 50	Poor, checked from outside varnish coat to metal

Sample cars were selected to illustrate these various classes, and photographs were taken of the different defective surfaces so as clearly to indicate to the eye what the different percentages meant.

17 The result of this examination showed that the exteriors, including the sides, ends and vestibules, were in fair condition. There were a few exceptions to this, but they amounted to less than 6 per cent of the total having serious varnish and surface cracks. Interiors were found generally to be in a poor condi-

tion. About 80 per cent of the equipment examined had the varnish checked through to the surfacer.

18 Some of these conditions developed after four to eight months' service, indicating either that an entirely new system of painting would be necessary to overcome these troubles, or that a more elastic paint would have to be used for interior finishing under the present existing practice of painting steel.

19 To obtain some data indicating what should be done to meet the conditions, preliminary experiments were made by painting a number of panels and baking them in a heated oven. Repeated experiments along this line indicated that artificial driers could almost, if not entirely, be eliminated in the paint formulae and that more elastic materials could be used without the aid of artificial oxidizing agents. It was also observed that the elastic varnish used on the exterior of the cars could, under this system, be used to advantage on the interior, and by the aid of the heat of the oven they could be dried to the desired hardness, permitting the rubbing with oil and pumice to get the "flat finish."

20 The outcome of the experiments indicated that it would be desirable to extend the experimental panels to a full size car and, therefore, a proper baking oven was planned that would accommodate one of the largest existing steel passenger cars for the purpose of baking each coat as applied to the exterior and interior surfaces.

21 This oven, as designed and built by the Pennsylvania Railroad Company at its Altoona Shops, is 90 ft. 3 in. long, 13 ft. wide and 15 ft. high. The frame work of this structure is made up of 3-in. I-beams for the sides, spaced 5 ft. centers. The roof framing is made of the same sections and curved to conform closely to the contour of the car roof. Each end of the oven has two large doors which can be readily opened and closed for the baking operation. The oven is lined on the inside with $\frac{1}{8}$-in. steel plate, and on the outside with galvanized iron of 0.022 gage. The 3-in. space is filled with magnesia lagging, thus effecting the needed insulation. The doors are insulated in a similar manner. Along the walls of the interior of the oven are placed 16 rows of $1\frac{1}{2}$-in. steam pipes, and along the floor, close to the walls, are arranged manifold castings with small lengths of pipe tapped into them at right angles. By this means over 2000 sq. ft. of heating surface is provided. A steam pressure of approximately

100 lb. to the square inch is used, thus making it possible to get an oven temperature of over 250 deg. fahr. Rectangular openings, made adjustable, are provided on the sides near the floor line, allowing the necessary admission of air for circulation. Four 8-in. Globe ventilators are spaced at equal distances in the roof, likewise provided with dampers to regulate the size of the opening. By this means of ventilation, fresh air, which is required for the proper drying of paint, is obtained, as well as providing for the egress of the volatile matter present. Automatic ventilation and steam regulation have not, at the present

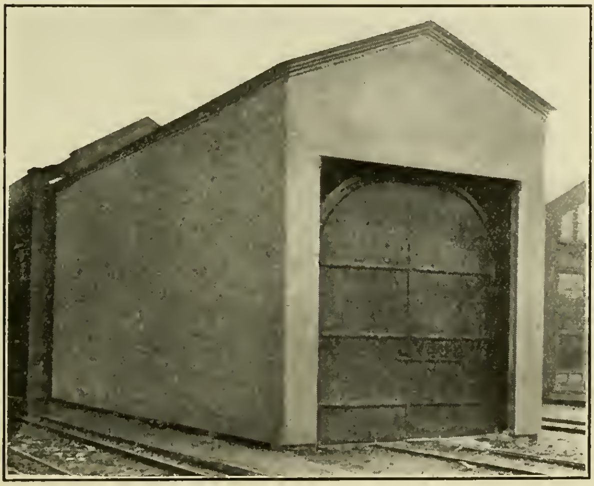

Fig. 1 Exterior Appearance of Oven

time, been applied, but these have been considered advisable, if the result of the experiment seems to warrant a more extended application of the practice.

22 A track is placed on the floor of the oven and connected at each end of the oven with other tracks leading into the regular paint shop where the different coats of paint are applied to the car before each baking operation.

23 Photographs of the general appearance of this oven from the outside, and one end of the interior with a car within the oven are shown in Figs. 1 and 2. Fig. 3 shows the steam piping in detail.

BAKING PAINT ON STEEL

24 The outline of painting a car in this oven is briefly as follows: First, a priming coat is given the exterior and interior of car, which is then moved into the oven and baked for three hours. The temperature at the start is about 160 deg., but rapidly rises

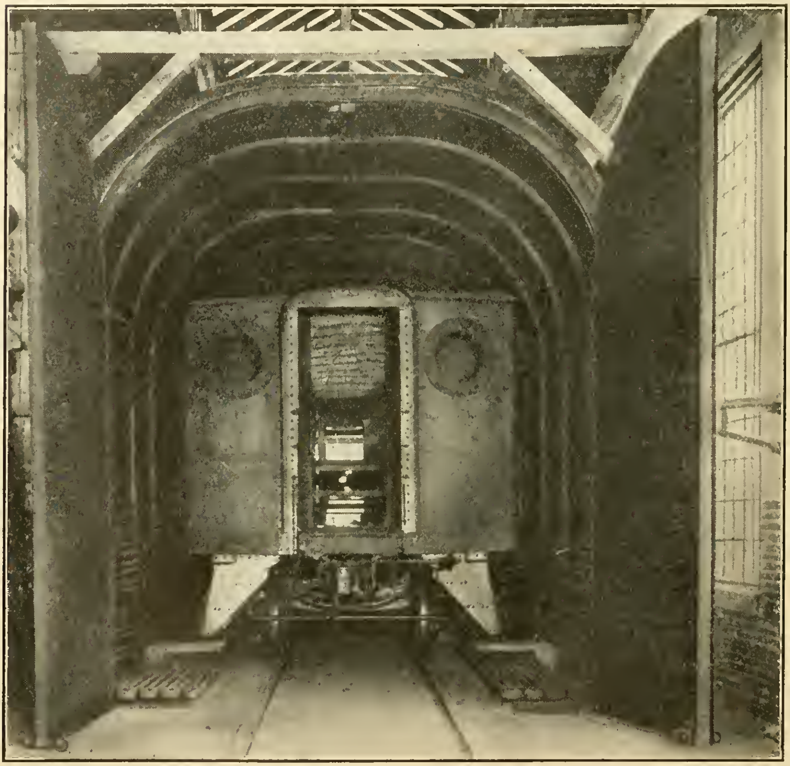

FIG. 2 VIEW OF INTERIOR OF OVEN SHOWING CAR IN PLACE

at about 1 deg. per min. until a temperature of 250 deg. is reached, requiring about 1½ to 2 hours. The oven is held at this temperature until the lapse of 3 hours, when the car is withdrawn, allowed to cool sufficiently to work upon, after which the surfaces are glazed and depressions and uneven places puttied. The car then receives its first coat of surfacer, is returned to the oven for 3 hours, baked and removed for additional coats which

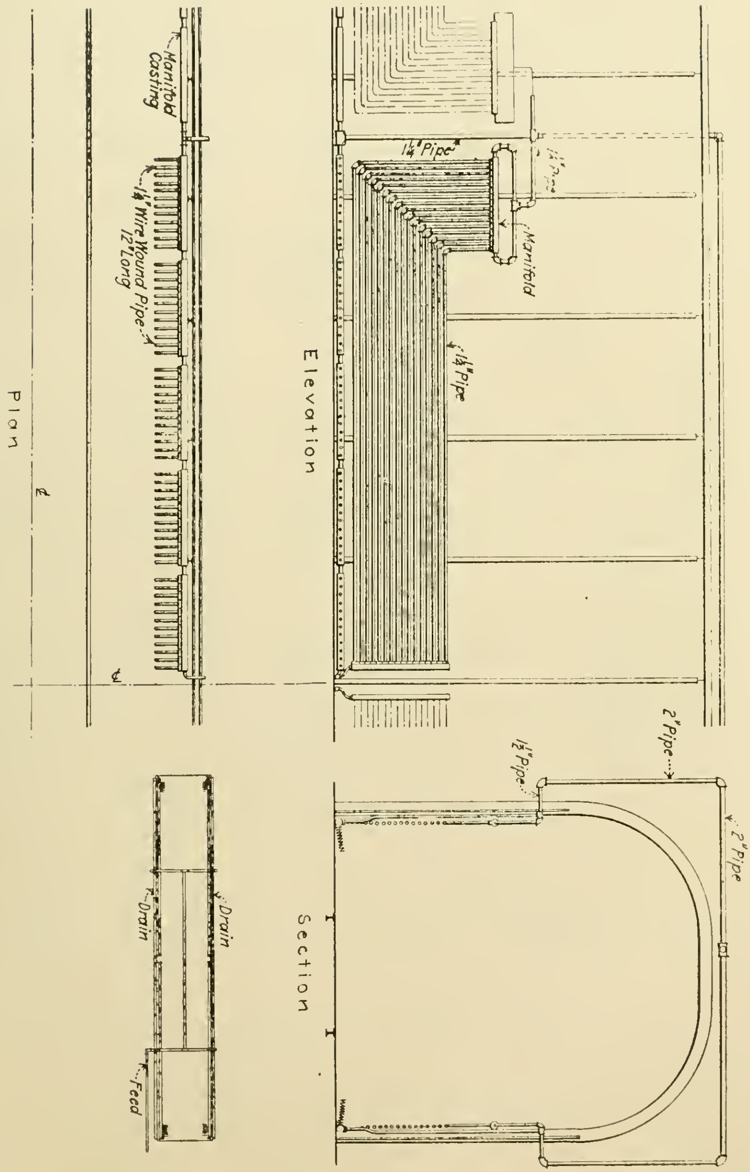

Fig. 3 Detail of Steam Piping

vary from two to three in number as the needs of the case require.

25 After the last coat of surfacer has been applied and baked, the outside surface of the body of the car is rubbed down with emery and oil to produce a flat and smooth surface. The various color coats used, such as tuscan red on the outside, pale green, bronze, and bronze green on the inside, are then put on. Two coats of each color are required to get standard shades. Each coat of color is likewise baked.

TABLE 1 TIME SCHEDULE FOR PAINTING EXTERIOR AND INTERIOR OF STEEL PASSENGER CARS

Outside				Inside		
Period of Work	Body	Roof	Trucks	Body Above Window Sills	Headlining	Body Below Window Sills
1	1st prime	1st prime	....	1st prime	1st prime	1st prime
2	glaze	....	....	glaze	glaze	glaze
3	1st surface	....	....	rub-ground	rub	rub
4	2d surface	2d prime	....	......	......	......
5	3d surface	....	....	......	......	......
6	rub	....	....	......	......	......
7	1st tuscan	3d prime	....	2d ground	1st green	1st green
8	2d tuscan	....	....	stipple	......	......
9	stripe and letter	....	....	......	......	......
10	1st varnish	....	truck	1st varnish	......	2d green
11	2d varnish	....	color	2d varnish	......	......
12	3d varnish	....	....	3d varnish	......	1st varnish
13	......	....	....	rub	2d green air dry	......

26 The car then receives the required lettering, striping, etc., after which the outside and inside surfaces get three coats of a high grade finishing varnish, especially adapted for the baking process. Each coat of varnish is baked at a temperature from 120 deg. fahr. at the start to 150 deg. fahr., which is maintained until the expiration of 3 hours. The interior surfaces of the car are then rubbed with pumice and oil, giving the " flat finish " effect desired, thus completing the painting of the car.

27 To illustrate better the schedule of operation followed, or the timing of the various coats, both for the outside and inside, to secure the most economical conditions, Table 1 is given.

28 All of the work done by the baking process of painting

can be accomplished in six to eight days, thus effecting a saving in time of about ten days as compared with the standard or present air drying system. Further, the paints and varnishes have been worked up so that they are especially adapted for this baking process, having greater elasticity. Exact formulae for the various mixtures are well defined, so that uniformity in material is expected, thus giving greater durability, better appearance and longer life for the paint work.

29 The checks and cracking previously found will be considerably lessened, if not almost removed. By oven painting the work is done under more uniform conditions, which at the present time are so hard to control. It enables the surfaces of the car to be heated uniformly and dried thoroughly, thus removing any objectionable moisture before the first priming coat is applied, which is a very desirable feature of the new method.

30 A considerable saving will be effected by the shorter time that cars will be held out of service when undergoing repairs and repainting in the shops. It is expected that dirt, soot, etc., will not adhere or imbed themselves so readily and that the general appearance of the car will be improved by the baking method.

31 This oven was placed in service the early part of this year and the results of the complete car at this time seem to justify the experiment. They seem to indicate that the results obtained from a small panel can be duplicated in the full size passenger equipment car and that, if this is the case, this method of painting can be used to advantage not only for the painting of steel passenger equipment cars, but for the painting of any other full size steel structure of a similar character where protection and finish are desired.

32 Results and indications at this time seem to justify our expectations that the new process of baking will give, over the present air drying system:

a Longer life of material applied.
b A general appearance as good or better.
c Less cost of material at no increase in the labor charge.
d Complete sanitation for old cars.
e A considerable saving of time for shopping cars, which results in a saving of shop space.

These advantages are offset by the initial cost of installation and operating cost of the oven.

PROVISIONS FOR ELECTRIC LIGHTING IN STEEL PASSENGER CARS

By H. A. Currie,[1] New York

Non-Member

Hardly more than perfunctory attention is, as a rule, given to the lighting equipment of a car by the car designer. After all other apparatus and equipment are taken care of, the lighting is considered and fitted as well as possible into the remaining space.

2 From a standpoint of practical consideration for the welfare of passengers, the lighting plays one of the most important parts; therefore, every effort should be made to arrange the light units so that no discomfort be occasioned, and to install the apparatus and wiring so that operating failures be reduced to a minimum. In this connection I might say that the United States postal authorities at Washington are going into this subject very carefully at the present time to insure fair treatment for their postal clerks in the railway mail service; very stringent requirements have been ordered both as regards general illumination and reliable performance.

3 The two essential considerations for the designing engineer to keep in mind in laying out his installation are:

- *a* The arrangement of parts in a manner to allow of easy inspection and repair.
- *b* Protection against mechanical injury.

Convenience and accessibility of apparatus, fixtures, junction boxes and wiring mean much to the inspector. It is a well-known fact that the average inspector will pay little attention to those parts which are difficult of access, and much better inspection work will result where parts are arranged in a get-at-

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able manner. It is of equal importance that the various parts be protected in such a manner as to avoid all possibility of injury to them while the car is in service. The other essential features of the lighting installation are discussed in the following paragraphs:

4 *Axle Generator.* The usual practice is to suspend the generator by swinging links at the inside end of the truck, and belt it to a pulley on the axle. For mounting the axle pulley a straight machined seat should be provided in all cases if electric lighting is planned or can be anticipated. Until recent years the universal practice was to provide the regulation tapered axle and allow the manufacturer of electric lighting equipments to adapt his pulley to an unsuitable seat in the best manner he could. The belt and pulley troubles which resulted were disproportionate to any possible advantage from retaining the tapered axles. It is customary for the manufacturer of lighting equipments to provide his own supporting structure adapted as circumstances permit for attachment to the truck. The resulting suspension is at best something of a makeshift.

5 It would be a consummation much to be desired if truck designers would provide a generator support built integral with the truck; the requirements are not difficult and it is certain that the generator builders would be glad to make their machines conform to the truck builder's suspension. As the matter is now handled, nothing causes them more delay and inconvenience than obtaining the numerous details of truck and underframe construction necessary for making an intelligent layout of the generator suspension. In designing the suspension it is desirable that the space required for the belt be kept as clear as possible. The end tie of the truck frame, if used, should not be deep and should be located at a level that will make it possible for the belt to straddle it. Outside brake beams when used are a necessary evil from the standpoint of generator location. Head room for the generator should be considered in laying out deep center girders, brake rigging and piping. All the open space that can be provided about the generator is desirable because it facilitates thorough inspection. The generator terminal board should be attached to the underframe of the car close to the generator and readily accessible.

6 *Battery Box.* On account of the obvious necessity for convenience in handling the heavy batteries, the battery box

location has practically been standardized. As the weight and dimensions of elements are almost identical, it is unnecessary to change the hanger design after a satisfactory arrangement has once been used.

7 *Charging Receptacles.* The charging receptacles have been allotted a permanent location on electric lighted equipment. Care should be taken to arrange the wire leading to the receptacles to prevent interference with brake rods, etc.

8 *Switchboard and Regulator Lockers.* (*a*) The switchboard locker should be so located as to be at all times easily accessible to the trainmen; no pains should be spared in the design and installation of the board; nothing but fireproof material should be used. A receptacle for spare lamps and a report card holder are convenient accessories. (*b*) The regulator locker is generally located under the switchboard and on the generator end of the car. Good ventilation is a necessity. Provision against dampness and dirt is imperative. The regulator lockers should be fitted with locks to guard against accidental or wilful interference with apparatus. In designing lockers for lighting apparatus it is recommended that liberal space be provided so that changing of equipment, repairing, inspecting and testing can be done to the best advantage.

9 *Conduit.* In steel-car construction, metal conduits are almost universally used. In the better type of steel car the interior conduits can be concealed behind metal molding and suitable outlet boxes designed to harmonize with the contour of the molding. Some designers are satisfied to have exposed conduit used exclusively throughout the car. In laying out wiring conduit, direct runs without sharp bends should be used. Care in locating the conduits will facilitate the installation of wires and prevent damage from moisture, etc.

10 *Fixtures.* Where side lighting is used, a satisfactory arrangement can be obtained by designing the fixture to meet the contour of the molding. In center deck lighting, it is advisable wherever possible to arrange the carlines so that a direct support to each fixture may be obtained. On platforms provision for one or two-lamp outlets is sufficient. A plain socket mounted on the platform ceiling has been used in some instances. A better arrangement would be a metallic reflector sunk flush in the ceiling.

11 *Emergency Lights.* It was formerly customary in applying electric light to retain gas lighting as a reserve. Increasing reliability of electric lighting apparatus has made this unnecessary and in the best present practice no gas equipment is provided. For emergencies it is customary to provide holders for candle lamps; but it is only on rare occasions that these have to be used, if the electric equipment is of a good modern type.

PROVISION FOR ELECTRICAL EQUIPMENT ON STEEL MOTOR CARS

By F. W. Butt,[1] New York

Non-Member

In providing for the electrical equipment on steel motor cars, several important points should be considered. On account of its metallic construction, the car becomes a negative conductor, or, in other words, the car is grounded, and all electrical apparatus must be well insulated against leakage of the electrical current.

2 Switches, circuit breakers, fuses, etc., should be so located that the arc when opening a circuit will not reach the metal structure of the car. In cases where space is limited, and it becomes necessary to locate circuit breaking apparatus in such a way that there is danger of the arc reaching the metal structure, suitable arc shields of non-conducting and non-inflammable material should be used.

3 Switches, terminals and other apparatus, having exposed live parts, should be protected against accidental contact by enclosing them in boxes or cabinets. This protection is most important where apparatus, such as mentioned above, is located in or near the space which is occupied by passengers.

4 It is sometimes found necessary on account of the restricted space in toilet rooms, motormen's cabs, postal and baggage compartments, etc., to attach electric heaters directly to the sheathing; the heater coils then are necessarily close to the sheathing, and as a means of protection to the paint and varnish thereon, an insulated backing should be applied between the sheathing and the heater.

5 Particular attention should be given to locking bolts, nuts.

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screws, etc., to prevent them working loose on account of vibration, especially those which are used to secure the apparatus. The vibrations of the motor gearing are transmitted to all parts of the car and they are more pronounced when the motor suspension lug is mounted on the truck transom, without the use of suspension springs. Vibration is more easily transmitted through the solid structure of steel cars than it is in cars of wood.

6 In the design of new cars it is sometimes found convenient to locate various members of the structure, especially in the underframe, so the apparatus can be suspended from them without the use of intermediate supports. This is desirable, as it is often found that many parts can be omitted from the car. Where heavy apparatus is to be suspended from intermediate supports, large heavy members are required, sometimes complicated in design in order to obtain clearance between parts of the structure or apparatus.

7 Where it is possible, apparatus hangers should rest on the members which support them and not depend entirely upon a vertically bolted or riveted connection. The hangers should be well braced, especially those which hang far below the underframe, to prevent swaying of the apparatus, due to the motion of the car. The hangers can be so designed as to provide the necessary bracing, but to accomplish this odd shapes are often required which increase the cost of manufacture. It is then desirable to provide hangers and separate braces of simple design.

8 When several switches, fuses and other electrical apparatus are required for the motor, control and auxiliary circuits, large switchboard area is necessary, and in some instances, the switchboard has been installed in one of the end bulkheads, occupying most of the space between the body corner and door posts. In recent steel cars, intermediate body end posts are used as part of the general scheme for anti-telescoping provisions at the end of the car. These posts extend from the body-end sill to the body-end plate, and it is recommended, in order to interfere as little as possible with the general anti-telescoping scheme, that two small switchboards be used, one placed in the bulkhead on each side of the body-end door opening, and located as high above the platform as the size of the boards will permit. This arrangement of switchboards provides for the use of short inter-

mediate body-end posts, extending upwards from the body-end sill to the horizontal frame member, located just below each switchboard and connected to the body corner and door posts.

9 In wooden car construction it is necessary to provide ground wires from the various electrical circuits to some part of the car which is a negative conductor. This is unnecessary on cars of steel construction, as the electrical circuits can be grounded at almost any part of the car structure.

10 The steel car is safer than cars of wood construction, as there is no danger of bad fires on account of short circuits. Parts of the structure of a steel car will not become alive, as is sometimes found in cars of wood construction.

11 The wiring conduit on a steel car should be provided for at the time the car is being designed. Unless this is done, difficult bends in the conduit may occur and it is sometimes found necessary to cut and reinforce the structural members.

AIR BRAKES FOR HEAVY STEEL PASSENGER CARS

By A. L. Humphrey,[1] Wilmerding, Pa.

Non-Member

Advancement in the development of air brakes has been no less contingent upon the development of rolling stock than the economic handling of traffic through the use of heavier and faster trains is contingent upon the advancements in motive power. A review of the history of railroad transportation development in this country will show a steady and unceasing advance from year to year. Equivalent advancement in the efficiency of appliances such as air brakes was consequently necessary in order that the control and safe handling of longer and heavier trains should not operate as a barrier to these developments.

2 A brief comparison of the conditions existing at the time of the introduction of the air brake with the conditions at present, will show that the advancement in rolling stock has been more rapid than those who have not been in close touch with the situation are likely to realize. For example, the weight on drivers of high-speed passenger engines has increased from 25,000 to 180,000 lb. The drawbar pull of locomotives has increased from 7,000 lb. to 30,000 lb.; working steam pressure has increased from 125 lb. to 225 lb.; weights of passenger cars have increased from 20,000 lb. to 150,000 lb. The schedule speeds of passenger trains have increased from 30 miles per hour to 65 miles per hour, and it is not uncommon for speeds to reach as high as 85 to 90 miles per hour.

3 Taking the average weights of trains and average speed at the time the air brake was introduced as compared with the

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trains and speeds of today, the weight per vehicle has not only increased nearly eight times, but the foot-pounds of energy to be destroyed is nearly 15 times as much. In order to meet the demands of modern service conditions as efficiently as heretofore, means should be provided for dissipating the total energy stored up in this swiftly moving mass in at least as short a time and distance as before. In fact it is desirable to do this in as much less time as is consistent with comfort to passengers and accuracy of control, in the case of service stops, and in as much shorter distance or time as may be possible in the case of emergency. Not only must the brake be automatic in its operation, but it must be capable at any time and under any conceivable circumstances to produce the maximum possible retarding force within as short a period of time as the known resources available and physical limitations will permit.

4 When we consider that it requires a distance of 8 to 12 miles for a locomotive of modern design, hauling a train of say ten cars, to accelerate to a speed of 80 miles per hour and that this same train should be brought to a standstill within the shortest possible time—or say in one-tenth of the distance required to accelerate to this speed—it is hardly conceivable that this can be done with the means available, which is a retarding force produced by frictional contact of metal shoes against the wheels, which is in turn limited by the adhesion between the wheels and the rail.

5 This factor, viz., the friction obtainable between wheel and rail and shoe and wheel is the basis on which we must start, and upon which we are limited, as to the amount of retarding force obtainable. It is therefore of first importance in designing an air-brake installation to give due consideration to the contact between the wheel and rail and the possible efficiency of the brake shoe. The air brake in itself is practically limitless in the amount of force obtainable, but the practical application of this force is where the line must be drawn. In this connection it is worthy of note that the brake shoe today has about four times as much work to do as it had 30 years ago. The chief effect of this, however, is to destroy the brake shoe at a much more rapid rate, without permitting any material lengthening of stopping distance.

6 The improvements made in air brakes in recent years, which have made it possible to control the present heavy high-speed

passenger trains with approximately the same degree of efficiency as the older forms controlled the equipment of their day, have been based on scientific principles and experience in obtaining reliable information and data. The matter of time of transmission of compressed air was not so important a factor with the shorter trains and slower speeds as it is today, where a train running at 80 miles per hour passes over a distance of 117 ft. per sec.; consequently a few seconds saving in the time of getting the brakes to fully apply is just so much relative gain in the time and length of stop. With the latest improved pneumatic equipment, the maximum brake cylinder pressure can be obtained throughout a modern train of ten cars in 4 seconds, which is the shortest possible time that this can be obtained by serial quick action through a train of this length. For the purpose of shortening this time serious consideration is being given by some railroad officials to the type of brake equipment used on the New York subway, and known as the "electro-pneumatic," which would not only tend to cut the time of full application in two, but by means of the electric control all brakes are applied simultaneously, which not only assists in shortening the stop but in preventing shocks, etc.

7 Another equally important factor now coming more prominently into use is the application of brake shoes to each side of the wheel, known as clasp brakes. The virtue of clasp brakes, however, is not so much in the aid they afford in shortening the stop as in the equalizing effects of pressure on the wheels, journal box bearings and trucks, the minimizing of lost motion which affects the brakes through increased piston travel, and the less tendency toward wheel sliding while the brakes are applied.

8 While a comparison of the relative merits of a brake equipment, as with most mechanical devices, is frequently based on their maximum capacity, it must be borne in mind that an air-brake equipment must be designed to include flexibility for service operation, in which it is operated 99 per cent of the time and during which time it should be capable of handling smoothly the extreme lengths of trains, while at the same time it must be capable and ready under all conceivable circumstances to produce the maximum permissible braking force in case of an emergency.

9 It is not especially difficult to increase the speed of a train from 30 to 40 miles per hour, but it requires a vastly greater

amount of energy to increase the speed from 60 to 70 miles per hour. In like manner, for any given increase in speed, the additional amount of work required of the brakes increases proportionally. If, therefore, the brakes for the heavier trains and higher speeds of today permit of stopping in about the same distance and with the same flexibility of control as could be done with brakes 40 years ago, and with the trains of that period, it is at least gratifying to know that the advancement made in this particular line of railroad development has kept pace as closely as it could consistently with the development in transportation facilities, through which its rate of advancement is largely controlled.

CAST-STEEL DOUBLE BODY BOLSTERS, PLATFORMS AND END FRAMES FOR STEEL CARS

By C. T. Westlake, St. Louis, Mo.

Member of the Society

Cast steel as applied to underframes and end frames of railroad cars is the result of careful design and painstaking, and thorough development of the art of casting in sand molds. These large steel castings are made in baked molds, confined in massive metal forms, by a special method that assures positively against swelling due to pressure of the inflowing metal, and yet permits yielding to the pressure of the contracting metal when cooling, so that the castings are very accurate in shape and close to size, and are free from shrinkage stresses.

2 Steel is an alloy of iron and carbon and differs from other alloys of iron by being capable of developing all its physical properties to the maximum degree. Its most distinctive properties are rigidity, ability to stand maximum forces without yielding; elasticity, ability to return to normal after being loaded to deflection; ductility, ability to stand distortion beyond its elastic limit without fracture; malleability, permitting it to be forged; tensility, high tensile strength; and weldability, permitting it to be welded by heating and hammering. These properties which steel possesses in a maximum degree distinguish it from all other alloys of iron.

3 Cast steel and rolled steel are produced by the same processes and of the same materials, are of the same chemical composition and have the same physical properties, and cast steel may be substituted for rolled steel, using the same fiber stresses, and its substitution is limited only by the minimum section that can be poured in the molds.

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4 As recently as 1893, cast steel was comparatively unknown in car construction, and in that year its introduction began in the use of truck bolsters for freight cars. This was followed a few years later by body bolsters or transoms, and it was only after their use on freight cars had demonstrated satisfactorily the reliability of the material and design, that attention was turned to passenger cars.

5 The double body bolster was first to receive consideration for passenger cars, and although, due to casting difficulties, its weight was at first excessive, it was quickly refined and assigned to its proper place with other cast-steel articles. It was found to be so much lighter, stronger and permanently effective than the built-up type, by forming a one-piece cradle or support for each end of the car body, that its use soon became almost universal in construction of passenger cars.

6 As the demand increased for stronger, safer and less combustible cars, the problem of replacing wood with steel developed many difficulties. The wooden car was the result of many years of experimenting, of cutting and trying with a material easily worked, but as one of the most valuable properties of cast steel is its adaptability to combining a multiplicity of complex parts into a single one of simple form, it was gradually developed from the double body bolster form, first to include end sills, then end and buffing sills; next the end and buffing sills were combined with longitudinal members extending to, and connecting with the double body bolster. Finally these parts, together with many others combined into a single simple member at each end of the car underframe, and comprising so many of the fixed parts that it is now only necessary for the carbuilder to connect them by center girders and to apply draft and buffing gears and the superstructure to complete the car frame.

7 The ideal underframe should have all connecting members in the same plane so as to avoid buckling due to eccentric loading; it should be so designed that each member will independently perform its individual functions, passing the stresses from one member to the other through the smallest number of properly aligned connections; and all should be so arranged in relation to each other as to form one powerful, compact, shock-absorbing element throughout the length of the car.

8 This can be accomplished to great advantage in cast-steel construction since the metal can be properly distributed in pro-

portion to the stresses. The gusset plates can be placed in the same plane as the flanges of intersecting members, and the whole reduced to minimum weight and to the smallest number of parts with practically no joints. It can be molded to any desired conformation, can be shaped to any curve, useful or ornate, without the use of expensive dies, can be provided with necessary projections joined to the main members by proper fillets. Openings may be provided with finished and reinforced edges, and all parts may be molded to symmetrical, pleasing contour, all edges rounded and a complete, practical, operative device, emanating from a single source furnished to the carbuilders ready for application.

9 As the rounding of curves necessitates the use of convex ends to the car body, the central portion of the ends is most exposed and liable to receive initial impacts, and this portion should be made strongest and most capable of properly transmitting the force of impacts to the balance of frame.

10 The underframe receives the force of end collision as a column load on its longitudinal members, while the end frame receives it as a transverse load on exposed members supported at their ends. As it is impracticable under these conditions to make the end frame equally as strong as the underframe, provision should be made for protecting the end frame against destructive forces. The underframe should be arranged so as to receive the initial impact, and if the encountered force is sufficient to destroy it, it should fail in such manner as to form additional protection to the end frame.

11 This is accomplished in cast-steel construction by arranging the parts of the longitudinal members so that when loaded to destruction by a collision force, the end portions yield upwardly, thus folding the exposed portion of the platform up against the end of the car body, and forming an addition to the end frame to assist in distributing the force to all the longitudinal members of the superstructure. The advantage of this construction has been demonstrated in wrecks when this identical action has taken place, the safety of passengers assured, and the property loss kept low.

12 The cast-steel platform as now provided for blind end cars, comprises the buffing sill having recesses for the buffer foot plates, holes and brackets for the buffer stems, pockets for the buffing device, brackets for safety chains, lugs for draft gear,

brackets for drawbar carry irons, anti-telescoping plate, extensions of the center sills and bottom chords of the side sills, all of the double body bolster members including side bearing arches and extending for a distance of over 14 ft. inward from the end of the car to a point considerably back of the truck center, and counting rivets, gusset plates and connecting angles, combining more than 1000 pieces into a single, powerful, shock-absorbing element of less weight than fabricated material of the same strength.

13 The cast-steel platform and double body bolster for vestibule cars comprises all the parts enumerated for blind end cars, and in addition, includes the exposed platform longitudinal members, step risers and end sill, measures over 17 ft. in length, is made of a single piece, and is also of less weight than fabricated material of the same strength.

14 Since the government has taken a hand in the construction of cars used in its service, stronger body end frames are being used, and as the end of the car is the first to encounter end collision forces, it reasonably deserves closer and more careful consideration.

15 Most damage is produced by end collisions and to protect life and property from them, the colliding object must be prevented from entering the car. To accomplish this, the end frame and end portion of underframe should be constructed so as to distribute the force of collision into all the longitudinal members of the car, passing it into the largest mass, utilizing every particle of available inertia to absorb the force without permitting it to reach and act upon the contents or occupants of cars.

16 The end frame proper should be designed so that when a single member is loaded, all will act with it, and this can be accomplished only by connecting them so as to form a single mass, and best by forming them in a single piece as in cast-steel construction.

17 In designing the cast-steel end frame we assume it to be a beam supported at its upper and lower ends and loaded at a point about 18 in. above its lower end. We provide connections between the end frame and balance of car frame of sufficient value to develop the full transverse strength of the end frame; the vertical members of end frame are connected by horizontal members so that in case the end frame is loaded to destruction the connections are sufficient to disrupt all the longitudinal mem-

bers of the car frame, and when they yield all parts will be forced toward the center of the end of the car and tend to prevent one car telescoping the other.

18 Cast-steel parts weigh less than built-up members carrying the same load since the metal in castings can be properly distributed in proportion to stresses. In built-up construction the metal overlaps at the joints and this, together with the rivet heads, makes an additional weight which in cast construction is avoided. In the latter, reliance is placed in a single solid member and, as there are no joints, there is no chance of their being imperfect or becoming loose.

19 The advantage in cast steel to the carbuilder is also very great. To produce a platform of the built-up type at least eight different classes of material are required. This comes from eight different manufacturers, frequently from as many different points of production, much of it in less than carload lots, and all has to be requisitioned, purchased, received, stored and recorded for use on each particular lot, and in order to reduce storage space and avoid congestion in the car plant, all deliveries have to be carefully and accurately timed, and followed up. Then each material has to be passed through the different departments of the car plant to be cut, shaped, punched, drilled and the same timing and tracing methods used, so as to have all parts completed at the proper time. When cast steel is used but one material is purchased from a single plant, only one piece is handled, that in carload lots, and when it arrives it is immediately ready and available for application without storage or re-handling, facilitating completion of the car by leaving more car plant machinery available for other work.

20 A plant capable of producing castings of this nature in quantities to meet requirements of the many car plants must have buildings of extensive area and equipment in proportion, as it ordinarily requires about ten days for a casting to pass through the various processes of casting, cooling, roughing, cleaning and machining, and an accumulation of ten days' output has to be constantly accommodated. All handling and conveying apparatus must be in duplicate so as to insure uninterrupted operation and machines for finishing must be of the highest grade and maintained in perfect condition to produce accurate and proper results.

21 In car construction cast steel stands preëminent as the best

material for reducing to the minimum the weight and number of parts while maintaining requisite strength and other essential properties, and its popularity and use will proportionately increase as its benefits and advantages become more generally recognized.

SPECIAL ENDS FOR STEEL PASSENGER CARS

By H. M. Estabrook,[1] Dayton, O.

Non-Member

After the passenger car had emerged from the stage-coach type of construction the box-like shape of car was introduced with straight longitudinal floor sills and with straight vertical side and end posts. These members were of wood, the ends of the longitudinal floor sills being tenoned into mortises in the wooden end sills. The vertical side and end posts were in like manner tenoned into the side and end sills at their lower end and likewise into the wooden side and end plates at their upper ends. These side and end posts were maintained in their several positions, by wooden spacing blocks or bridging, and the whole structure tied together by means of iron rods and bolts. These spacing blocks served further the double purpose of affording a foundation for securing the outside panels and the wooden interior finish.

2 Several types of roof were quite prevalent in early passenger car days, among them being the round top or omnibus roof, which has again made its appearance in steel passenger cars in some parts of our country. Another type of roof was the Ogee, or turtle-back, and later came the monitor, or raised deck roof. The prevailing type of hood projection over the platforms was the " duck's bill " type, as illustrated in Fig. 1, which also furnishes a good idea of the framing employed in those days. Fig. 2 shows end framing of these same cars.

3 A little later the projecting platform hood was changed from the " duck's bill " type to the bull-nose type. Figs. 3 and 4 show respectively a longitudinal section and exterior of these cars. Fig. 5 shows the end construction and Fig. 6 the standard framing employed in the first bull-nose hood cars

[1] President, Barney & Smith Car Company.

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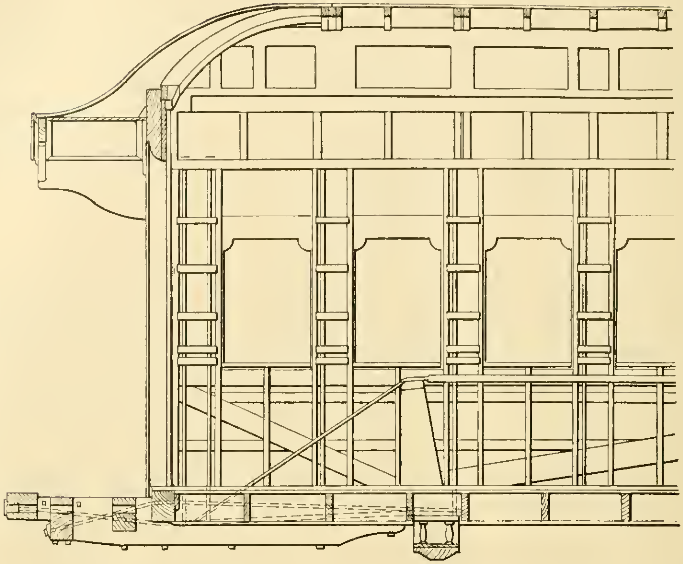

FIG. 1 "DUCK'S BILL" TYPE OF HOOD PROJECTION OVER PLATFORMS

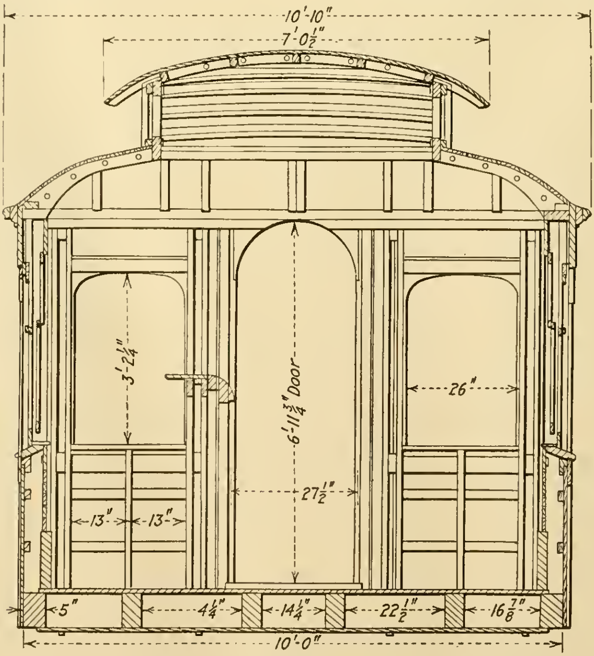

FIG. 2 END FRAMING FOR "DUCK'S BILL" HOOD PROJECTION

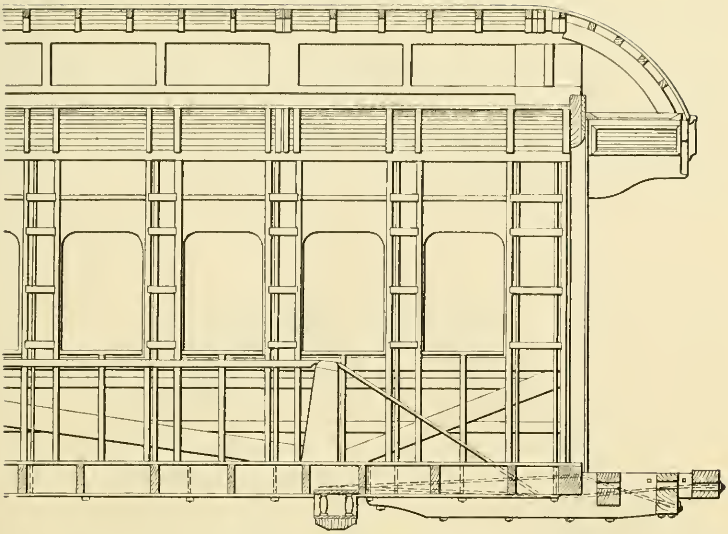

Fig. 3 Section of Bull-Nose Type of Car

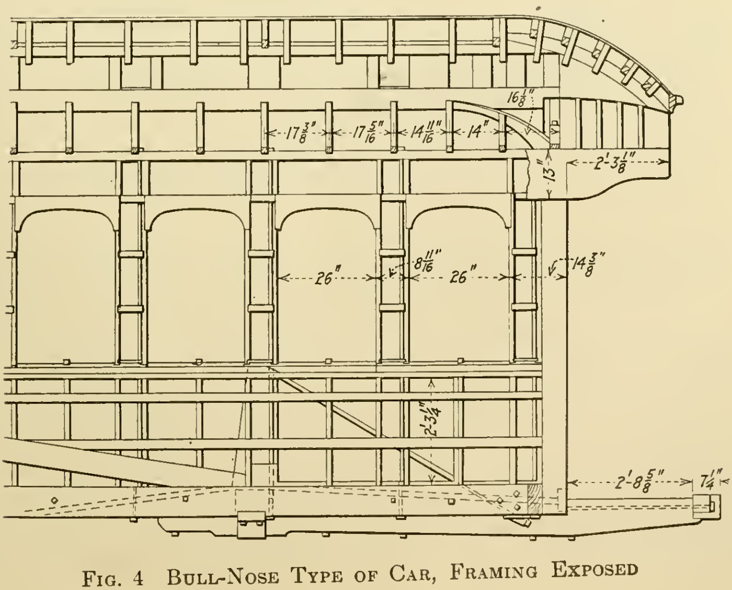

Fig. 4 Bull-Nose Type of Car, Framing Exposed

in the early eighties. Up to the middle eighties no systematic attempt had been made to strengthen the ends of cars. The platform members were all of wood and the end framing of the car had not experienced much change in the way of strengthening from the earlier types. With the advent of the narrow vestibule in 1887, which was immediately followed by the broad vestibule in 1888, came the demand for a stronger end.

4 About the year 1890 there was brought into use what was

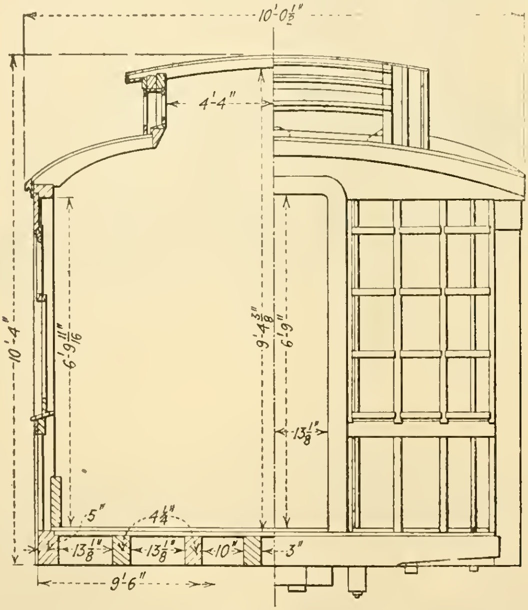

Fig. 5 End Construction of Bull-Nose Type of Car

known as an "anti-telescoping" end framing. This construction consisted of double side and end sills with a steel plate 8 in. by ½ in. from 18 to 24 ft. long, sandwiched into the double side sill, with the end of these plates turned so as to form a foot against the end sill. The double end sill had a steel plate 8 in. by ¾ in. and the length the width of the car, sandwiched into the end sill. The end posts of the car were reinforced by steel bars 3½ in. by ¾ in., extending downward through and bolted through the sandwiched end sill and having their upper ends extending upward and bearing on and bolted through a steel plate 6 in. by ⅜ in., which was bolted to the oak end plate of

the car. This stiffening plate extended across the width of the car and the ends of the steel plate being turned so as to form a foot upon the side plate of the structure. This anti-telescoping construction is illustrated in Fig. 7. This design of end framing came into general use throughout the country and is in use today in the majority of wooden passenger cars built since 1890. It is interesting to note that this anti-telescoping framing is the same, with some modifications and additions, as was adopted by the United State Government for the construction of full postal cars and known as Specification No. 1.

5 Somewhat later this type of end framing was elaborated upon by the use of a heavy steel angle flitched into the end sill, with the end still further reinforced by a 20 in. by ½ in. steel gusset plate on the under side of the sills, and by the use of steel Z-bars in the end posts and a heavy steel angle introduced into the construction of the end plate of the car.

6 The increased weight of the vestibules and anti-telescoping end framing developed the necessity for a stronger platform construction than the old style wooden platform member that had been used for many years. About the year 1895 the standard steel platform, composed of steel I-beams, came into general use, and was employed continuously until the advent of the steel car superseded it by other designs.

7 Notwithstanding the frantic efforts of Congress toward the general adoption of steel passenger cars, it has been stated upon reliable authority that no vestibuled wooden passenger car, in the construction of which was employed the anti-telescoping end framing, in a straight-on end to end collision (although frequently having the ends concaved) has ever had the end crushed in to the extent of the adjoining car body telescoping and entering it.

8 The United States Government in seeking to strengthen the end construction of postal cars adopted this form of anti-telescoping end framing with the addition of two 7-in., 23.46-lb. steel bulb beams on either end of the car. These bulb beams have their flat base resting against the outside of the reinforced end posts of the car, being located in line with and immediately behind the vestibule diaphragms and face plate. At its lower end, this bulb beam has the head and web notched out with the base flange extending downward through the flitched end sill. the main body of the beam resting upon the 1 in. thick steel plate

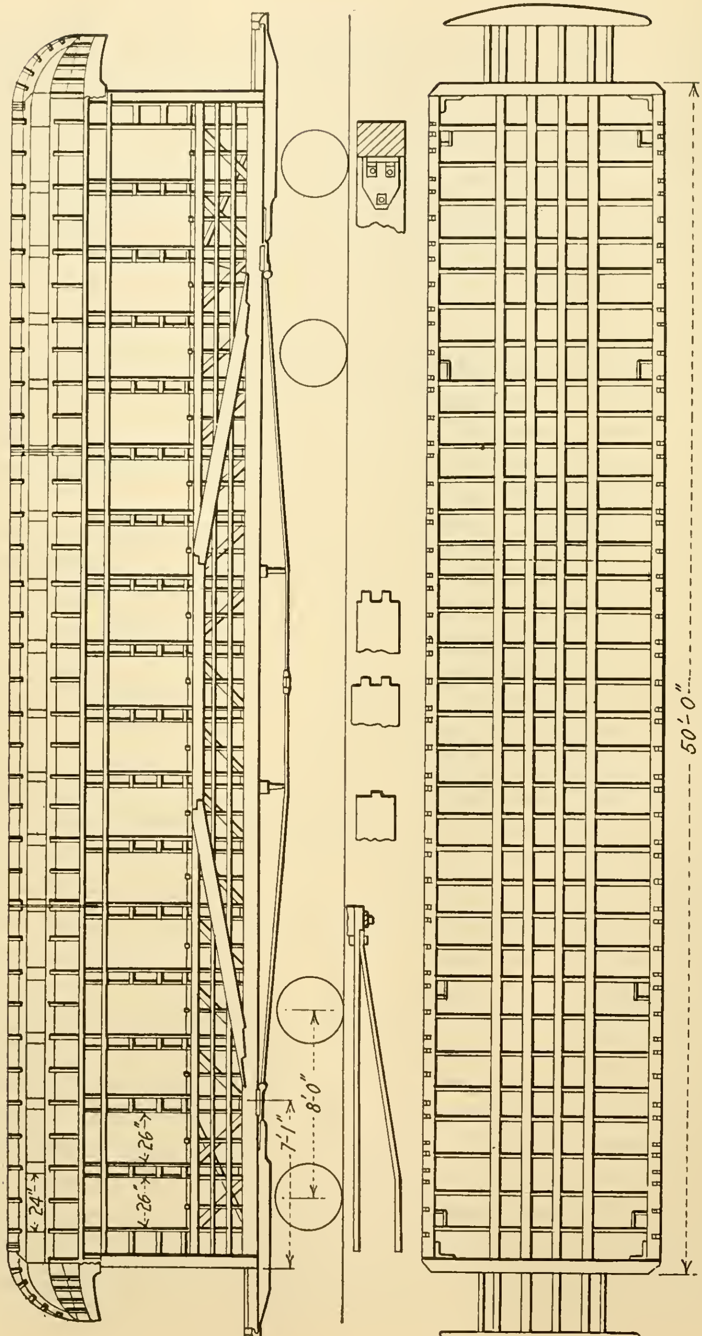

FIG. 6 STANDARD FRAMING EMPLOYED IN FIRST BULL-NOSE CARS

on top of the buffer beam. At the upper end these bulb beams have the web and bulb head sheared diagonally so the base flange extends upward on the outside of the end plate of the car framing, and through this flange passes the top piston stems of the vestibule mechanism. This type of construction is now obsolete

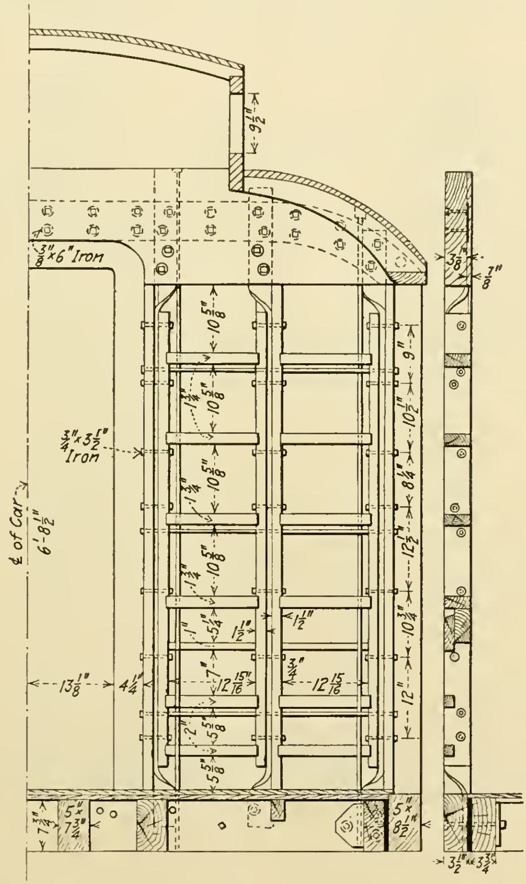

Fig. 7 Anti-Telescoping Iron End Framing

in postal cars, Congress having enacted a law requiring them to be of steel construction.

9 When the steel passenger car made its appearance about the year 1905, the passenger car entered a period of transition and evolution from which it has not yet entirely emerged with a recognized standard form of construction. The wooden car

had attained a degree of uniformity that established it as an accepted standard. In the construction of the early steel passenger cars, as was probably natural, an attempt was made to follow closely the lines employed in the construction of wooden cars, with the result that the first steel cars were inferior in strength of end construction to the prevailing wood construction, but

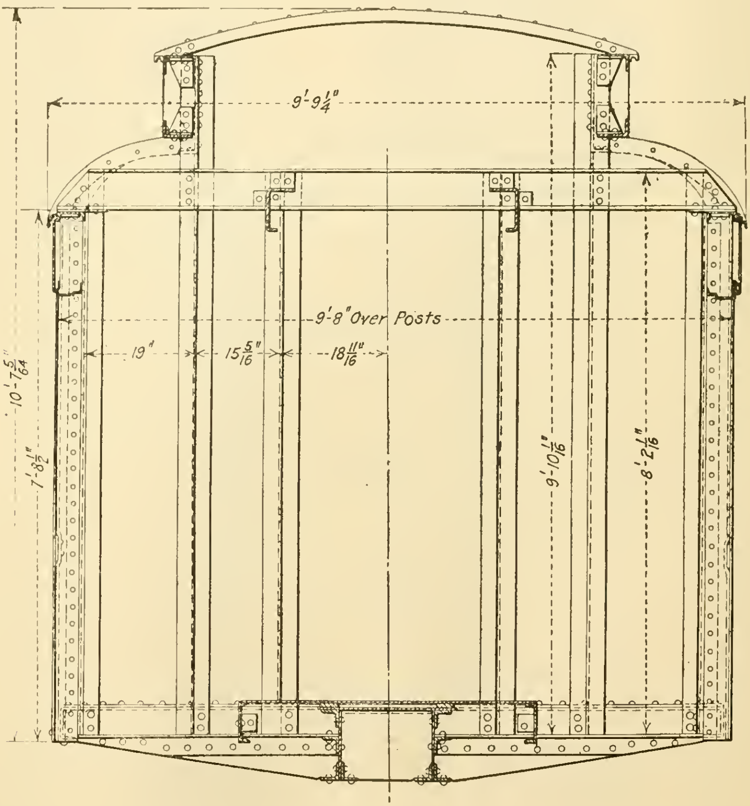

Fig. 8 Body End Framing, Type shown in Fig. 9

the evolution has been rapid, one improvement following close upon the heels of another. In the entire history of car building, there has probably not been devoted so much concentrated thought and study to the improvement in design, by the most expert engineering talent of the railroads and car builders, as has been shown since the introduction of steel cars. This has resulted in rapid improvement of end construction until we

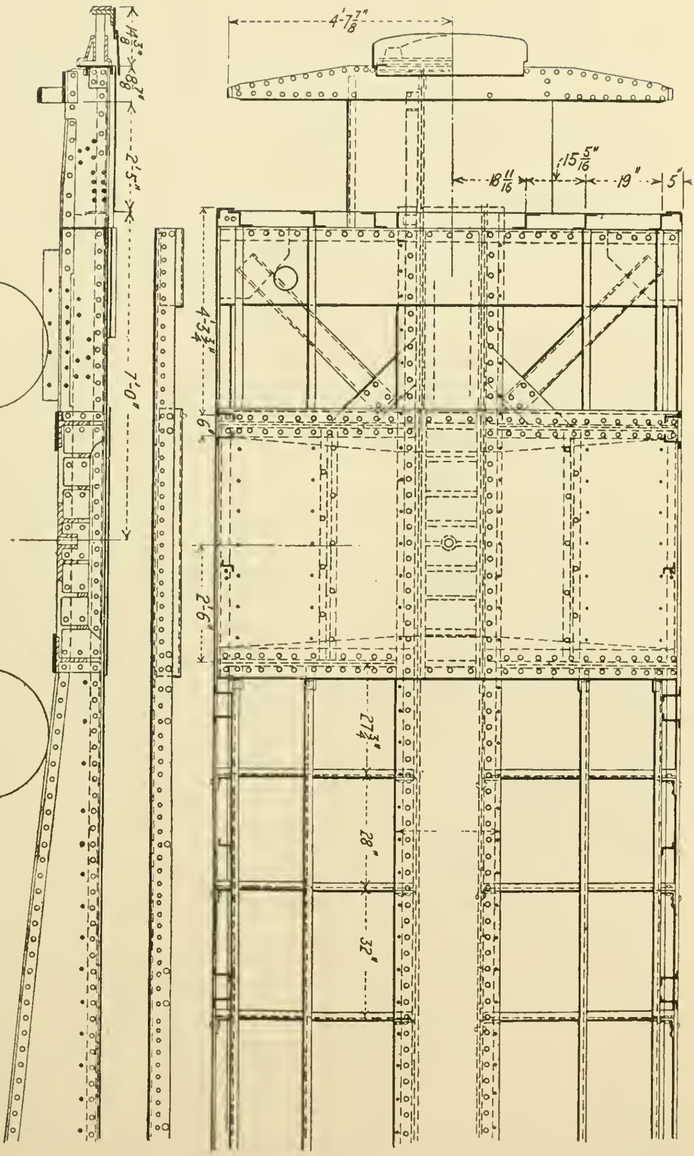

FIG. 9 STEEL CAR CONSTRUCTION, CENTER SILLS EXTENDING FULL LENGTH OF CAR

have today reached a design that is considered practically standard. This development has no doubt been hastened by the action of Congress relative to steel postal cars and the coöperation of committees of the railway mail service, the railroads and the car builders, to the end that a standard specification for the strength of the various parts of the car, and especially the end construction, has been adopted by the Postoffice Department in which it is provided that:

The maximum end shock due to buffing shall be assumed as a static load of 400,000 lb. applied horizontally at the resultant line of forces acting as the center line of the buffing mechanism and at the center line of draft gear, respectively, and shall be assumed to be resisted by all continuous longitudinal underframe members below the floor level, provided such members are sufficiently tied together to act in unison.

The sum of the section moduli of all vertical end members at each end shall be not less than 65 and the section moduli of the main members, either forming or adjacent to the door posts, shall be not less than 75 per cent. of this amount. The horizontal reactions of all vertical end members at top and bottom shall be calculated from an assumed external horizontal force, applied 18 in. above the floor line, to all vertical members in the proportions given, such force being of sufficient amount to cause bending of all vertical members acting together, and top and bottom connections of vertical members shall be designed for these reactions. Except where vertical end members shall bear directly against or be attached directly to longitudinal members at either top or bottom, the assumed reactions shall be considered as loads applied to whatever construction is used at end sill or end plate and both these last named members shall have section moduli, respectively, sufficient to prevent their failure horizontally before that of the vertical end members. All parts of the car framing shall be so proportioned that the sum of the maximum unit stresses to which any member is subject shall not exceed the following amounts in pounds per square inch—these stresses, unless otherwise stated below, are for steel having an ultimate tensile strength of from 55,000 to 65,000 lb. per sq. in.:

Bolsters of Rolled Steel—Stress shall not exceed 12,500 lb. per sq. in.

Sills and Framing of Rolled Steel—Stress shall not exceed 16,000 lb. per sq. in.

When cast steel is used the allowable stresses may be the same as for rolled steel except tension stresses, which must be at least 20 per cent less than those allowed for rolled steel, as specified above.

10 To meet these requirements, there are at this time three distinct forms of construction employed: The one most generally employed is illustrated in Figs. 8 and 9, which is composed of rolled-steel sections with the center sills running the full length of the car from buffer beam to buffer beam. Another type is that in which the rolled steel center sills connect at the bolster with a steel casting, forming a combined body

bolster, center and side sills, and end sills, as illustrated in Figs. 10 and 11. Another type is that in which the rolled-steel center sills connect at the bolster with a steel casting, forming a combined body bolster, center and side sills, end sill and the entire end frame of the car, as illustrated in Fig. 12.

11 In the first form of construction, shown in Figs. 8 and 9, rolled sections are employed entirely. The members forming the center sill construction extend the full length of the car from one buffer beam to the other and all other longitudinal members, such as side sills, belt rail, etc., extending the full length of the car body and in the case of vestibuled cars, the rolled section side plate extends the full length of the car from one vestibule corner post to another. The end sill is usually composed of pressed or rolled shapes riveted to the center-sill construction and extending laterally outwards to the sides of the car, the ends of the side-sill members butting against and being riveted to these end-sill members. The upper end plate of the car is composed of rolled or pressed sections extending in one piece across the width of the car and attached to the longitudinal side plates by connecting angles and gussets. To this end plate are also attached the longitudinal members of the upper deck sides. The end posts are rolled or pressed sections, usually Z-sections, extending downward to the bottom line of and riveted to the end sill. The upper ends of these posts extend upwards to the top line of and are riveted to the end plate. The nose piece or buffer beam is composed of rolled channels with their flanges turned inwardly towards each other, presenting their smooth surfaces on the outside, these channels being formed to suit the contour requirements of the vestibule, the channel members forming a box construction with top cover plates.

12 This buffer beam extends across and is riveted to the outward ends of the center-sill construction, from which it will be observed that the purpose of this design is to transmit the end buffing shock to the center-sill construction. The vestibule corner posts are rolled channel or Z-sections, whose bottom ends extend down into and are riveted to the outer ends of the buffer beams and whose upper ends are riveted to the vestibule end plate and to the upper longitudinal side plate of the car body, which projects beyond the end of the car body to meet and to connect with this vestibule corner post. The center vestibule posts are 6-in. I-beams whose lower ends extend downward

through and are connected to the buffer beam member and whose upper ends extend upward to and are connected to the vestibule end plate steel angle. Between the upper ends of these center vestibule posts and the end of the car body, are longitudinal compression members in the form of steel channels or angles. These rolled section corner posts, door posts and vestibule door

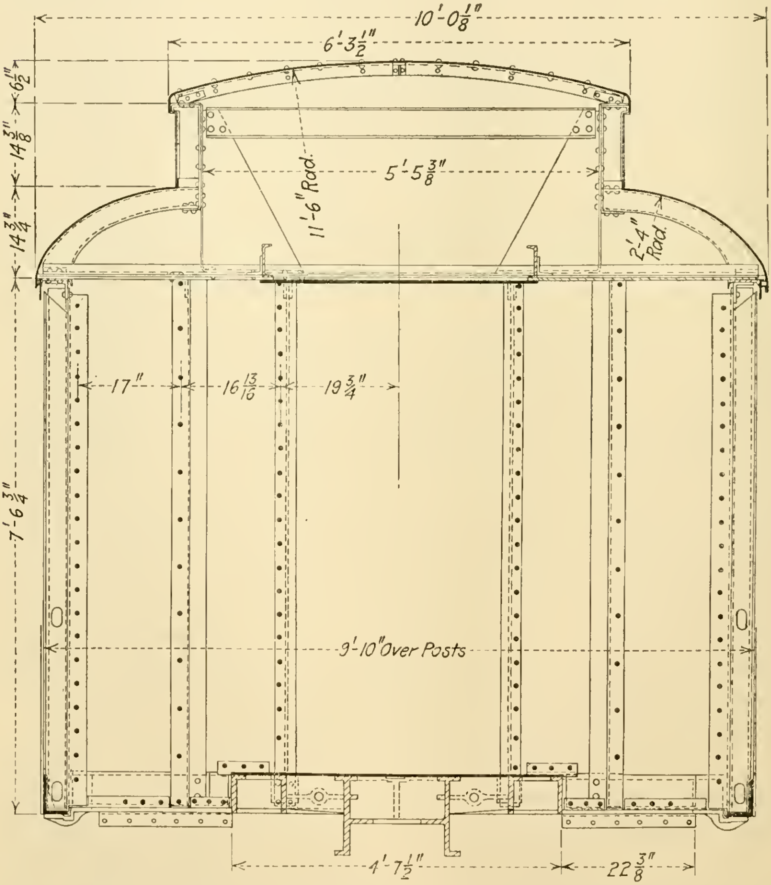

FIG. 10 BODY END FRAMING, TYPE SHOWN IN FIG. 11

and corner posts, are encased in light steel casings formed to give them the finished appearance of the same members in a wooden car.

13 In stub-end cars of this type of construction, the buffer beam is of considerably heavier construction than in the vesti-

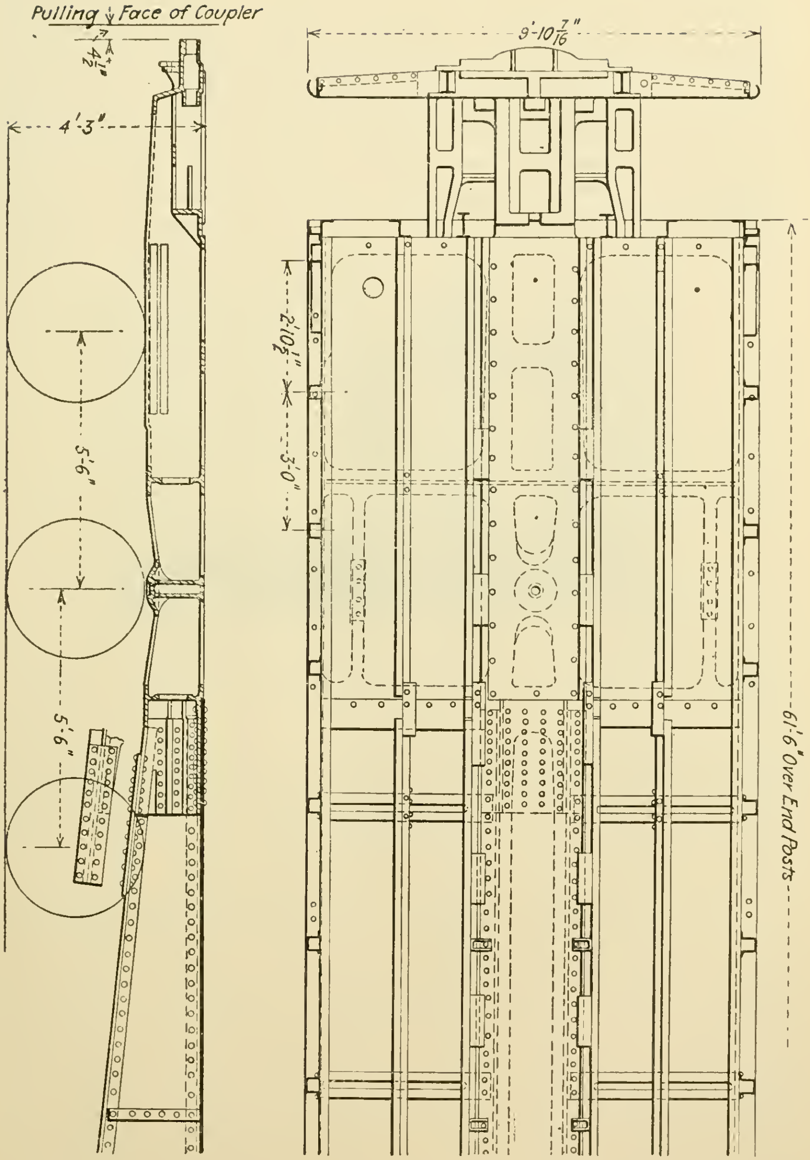

FIG. 11 STEEL CAR TYPE, CENTER SILLS CONNECT AT BOLSTER WITH A STEEL CASTING

bule car, and is usually composed of a built-up box construction or a one-piece steel casting, this buffer beam being secured immediately to the outside face of the end sill. In this construction there is usually employed a much heavier vestibule center post than in the vestibuled car. These vestibule posts, usually being a 12-in. I-beam, are located immediately in line with and behind the vestibule diaphragm and face plate. The end-post construction is much the same as described for the vestibuled car, there being a difference, however, in the construction of the end plate, which in the stub-end car is a pressed channel section

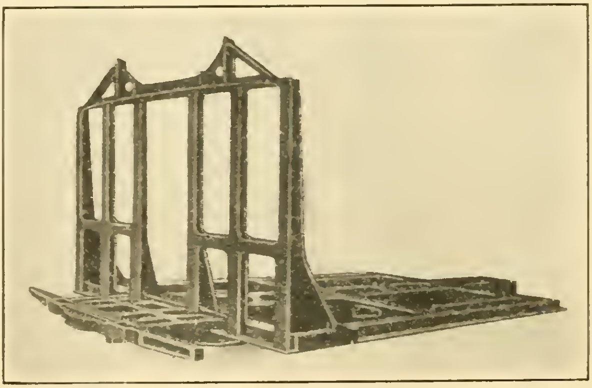

FIG. 12 INTEGRAL STEEL CASTING USED IN END FRAME CONSTRUCTION

formed to suit the contour of the car end, this channel end plate being placed across the end of the car in a horizontal plane, and into and riveted to this channel end plate are the upper ends of the corner posts, end posts and vestibule posts.

14 In the second type of construction referred to, a steel casting is employed forming the body bolster and platform to which the center-sill construction is riveted to this steel bolster. This construction is illustrated in Figs. 10 and 11, from which it will be observed that the center sill construction, the end sill, platform and buffer beam are all embodied in one steel casting. The end-post construction, the corner posts, vestibule corner and center posts are practically of the same construction as described for the built-up type, the difference being in the method of attaching the lower ends of these posts. The steel casting have openings or pockets in the end sill and buffer beam members, in which the lower ends of these posts rest and are riveted to the

casting. The construction of the end of the car body, the vestibule and hood are substantially as described for the built-up construction.

15 This type of construction for the stub-end car is substantially the same as that just described, the exception being that the steel bolster and end-sill casting takes the place of the built-up type of center and end-sill construction, the end post, corner post and upper end construction being identical in the two types.

16 In the third type of construction referred to the entire bottom framework of the car from the bolster outward to the platform and buffer beam, is one integral steel casting, and the entire end framing of the car is one integral steel casting, as illustrated by Fig. 12.

17 In referring to the three types of construction just outlined, it must be understood that reference is made to them only as types, and no attempt is made to describe the construction of any one railroad or carbuilder in particular, or to undertake to establish any of the forms described as being a standard, as the details of construction vary to a considerable degree with different railroads and builders.

18 It is of course apparent that the weight of the steel car is much greater than a car of the same size of wooden construction, and that the wooden car possesses in itself a natural elasticity to absorb buffing shocks such as are produced by collision that the steel car does not furnish. Hence, in the development of the steel car, with the enormous increase in weight of trains and the high speed at which they run, there has been a growing tendency to increase the strength of the structure with the view of making it as nearly indestructible as possible in order to compensate for the absence of elasticity. It is also apparent that, notwithstanding the strength of the structure, if it encountered an opposing force of sufficient magnitude, it might be annihilated, and so this strengthening process, and the increasing weight and speed might go on indefinitely without furnishing the result sought for. It is equally true that if the structure is designed for such strength as to be indestructible, when the two opposing forces meet, the movable objects within the cars, which is the human load, must suffer the damage. To avoid this possibility the idea has been evolved to construct that portion of the end of the car between the end of the main body and the vestibule face plates, these members being all such parts as are embraced in the platform, vestibule and hood covering the

vestibule, so that it will collapse under a less shock than would be required to crush in the end of the car body itself.

19 This idea is based on the theory that in a train in which there are say ten vestibuled cars, there is the space between the main bodies of each two coupled cars occupied by the platforms

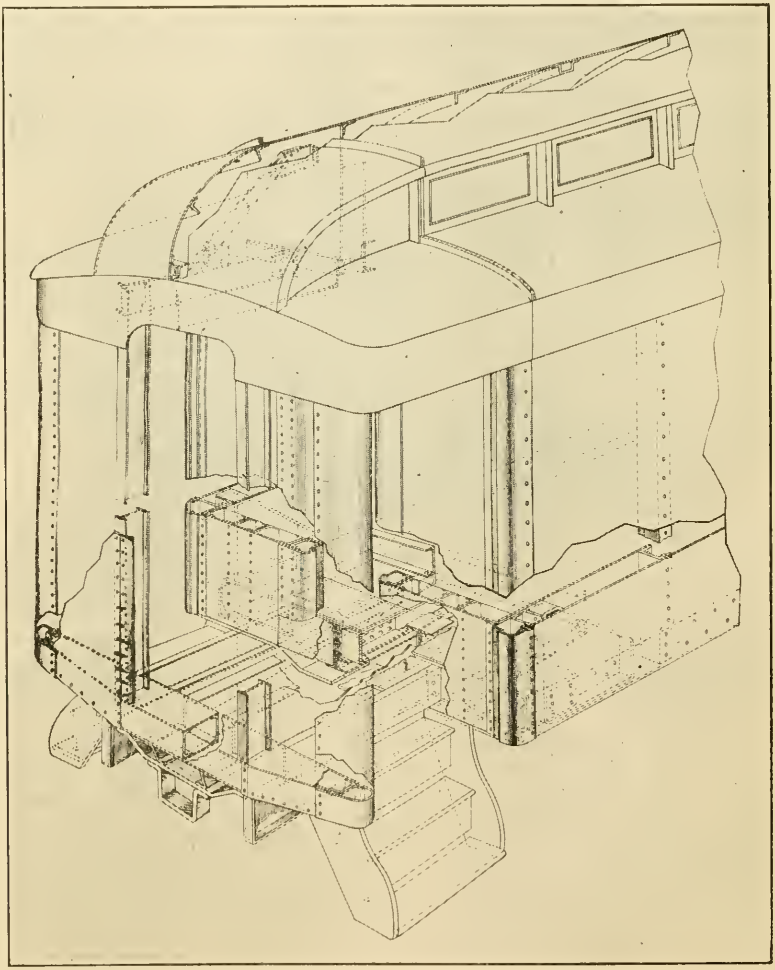

Fig. 13 Collapsible Vestibule constructed entirely of Steel

and vestibules of approximately 8 ft., or in a ten-car train a space of approximately 80 ft., of shock absorbing space, which, if properly utilized in the instant of collision, would remove to a large degree the shock and resultant damage to the car body

itself and likewise lessen the possibility of damage to the persons of the passengers. From this idea has developed what is termed a collapsible vestibule. It is generally conceded that if

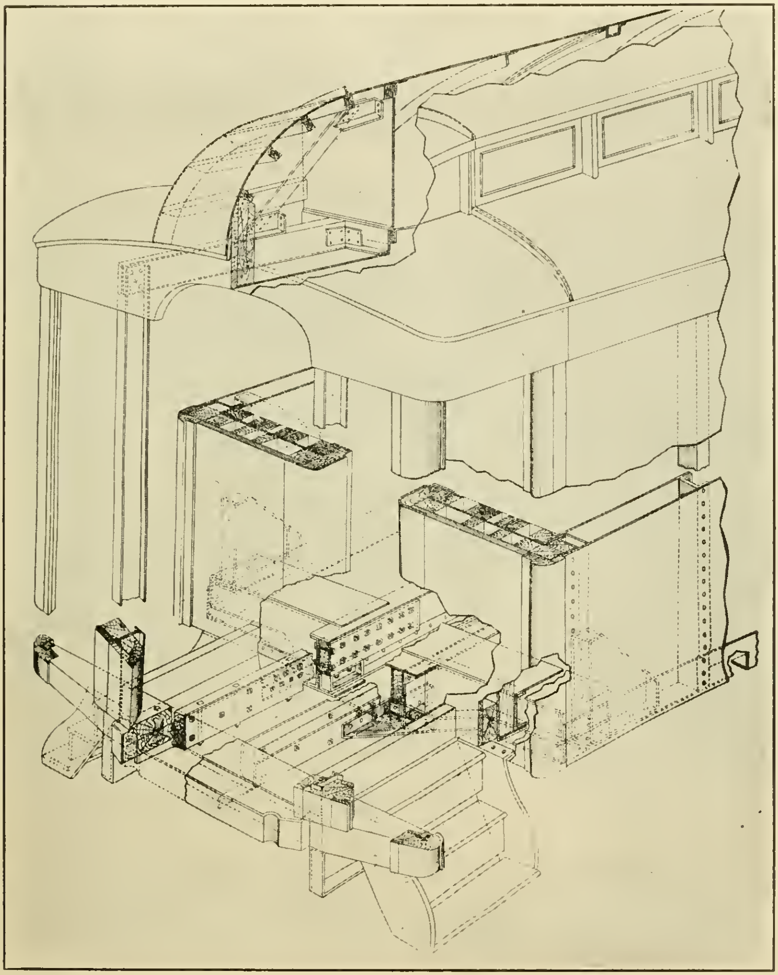

FIG. 14 COLLAPSIBLE VESTIBULE MADE OF A SERIES OF WOODEN POSTS TO SECURE ADVANTAGE OF ELASTIC AND CUSHIONING PROPERTIES OF WOOD

two vestibuled cars coupled together could maintain their respective horizontal planes at the instant of shock due to collision, there could be no telescoping and that telescoping is due to one car assuming, at the instant of collision, a higher or lower

horizontal plane than its adjoining neighbor, causing one to ride the other with the resultant telescoping effects.

20 It is generally conceded, that in cases of two cars tending to telescope, the point of maximum shock is never over 20 in. above the floor line. In the Government postal car specifications, this point has been definitely fixed at 18 in. above the floor line, and with this in view the end posts are reinforced for a distance of about 4 ft. above the floor line by steel angles riveted to the Z-bar end posts.

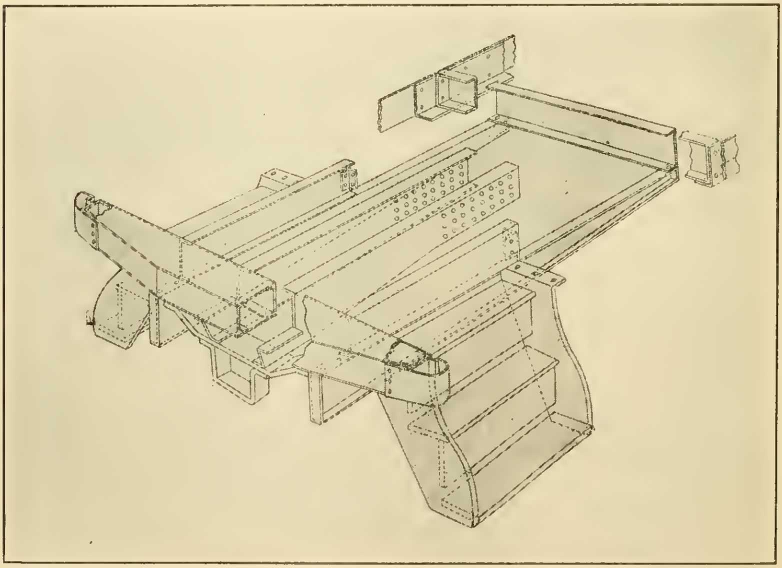

Fig. 15 Skeleton of Platform Members for All-Steel Construction

21 A general idea of this collapsible vestibule is afforded by Figs. 13 and 14. Fig. 13 shows the construction entirely of steel, while Fig. 14 shows a series of wooden posts and platform and vestibule members in addition to the steel members to secure the recognized advantage of the elastic and cushioning properties of the wood.

22 In this construction the longitudinal sills and floor members are designed to stop at the end sill of the car body proper, the end of which is sheathed with a heavy steel plate extending in one piece vertically from the roof downward to the bottom of the end sill. If the shock of collision is not entirely absorbed by the vestibule members before the end of the car body proper

can be crushed, this plate will tend to pull the roof downward and cause the direction of the oncoming car to deflect obliquely upwards instead of the two cars telescoping. Further to offset the effect, should the two cars change their horizontal planes in collision, pressed steel shapes in the nature of anti-climbers, are placed below the buffer beam and platform.

23 Fig. 15 shows the skeleton of the platform members for the all-steel construction, and Fig. 16 shows the skeleton of the platform members where wooden features are employed.

24 The vestibule diaphragm posts are constructed of heavy

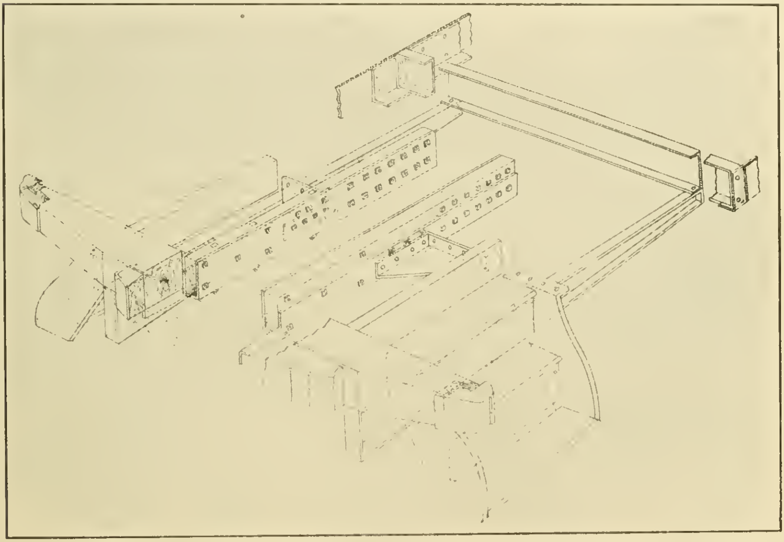

Fig. 16 Skeleton of Platform Members, Steel and Wood Construction

steel I-beams rigidly secured at the bottom to the buffer beam and at the top to the vestibule end plate and longitudinal braces.

25 The platform, vestibule and hood members are designed with a view to withstanding all shocks incident to regular service, but in abnormal shocks, such as would result from collision, the rivets connecting the various members would shear off with the exertion of less energy than would be required to crush the end of the car body, thereby causing the vestibule to collapse, absorbing the shock and furnishing a cushion between the two car bodies proper. It is assumed that in case of a collision these

would be the only parts seriously damaged, and the car could be repaired and replaced in service with a minimum of expense and delay.

26 The entire collapsible vestibule, comprising the platform, vestibule and hood, is constructed as a unit, detachable and separate from the car body proper and can be applied after the car is built or in the alteration of cars already built and is equally applicable to cars of either steel or wood construction.

27 The object of the collapsible vestibule is, first, to protect the lives of the passengers and secondly to protect the body proper of the car from serious damage.

INDUSTRIAL MANAGEMENT

At the Annual Meeting of the Society in December the Sub-Committee on Administration presented for discussion majority and minority reports reviewing the present state of the art of industrial management. These reports were printed in the November Journal; the discussion followed in March. Herewith is published additional discussion together with the closure.

DISCUSSION OF REPORTS OF SUB-COMMITTEE ON ADMINISTRATION ON THE PRESENT STATE OF THE ART OF INDUSTRIAL MANAGEMENT

Frank B. Gilbreth. The report is especially valuable for the reason that it emphasizes the fact, which has long been realized by those engaged in the work of installing scientific management, that transference of skill is one of the most important features.[1] They do not, however, make sufficiently plain that such skill and the experience which precedes it must be measured and recorded before it can be most efficiently transferred.

A better name for scientific management is "measured functional management." It is not sufficient to call it "labor saving management" for it deals with more than labor and labor saving. It is a way for obtaining methods of least waste. It not only saves useless labor, but it improves labor conditions; improves quality of product; prolongs the period of the worker's productivity; conserves, teaches and transfers skill and experience. The committee have caused the Society and the world to recognize at last the importance of the feature of the transference of skill, but they apparently still lack appreciation of the even greater feature of the recording and transference of experience of Mr. Taylor's measured functional management and of micromotion study. Mr. Taylor's system is best described in his writings entitled A Piece Rate System, Shop Management, and

[1] See Primer of Scientific Management, F. B. Gilbreth, p. 56; Psychology of Management, L. M. Gilbreth, chap. 8; Motion Study, F. B. Gilbreth, p. 36.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

On the Art of Cutting Metals, published by the Society, and Principles of Scientific Management, published by Harper & Bros.

As brought out in the report, the importance of transference of skill was realized many years ago. Studies in division of work and in elapsed time of doing work were made by Adam Smith, Charles Babbage, M. Coulcomb and others, but accurate measurement in management became possible when Mr. Taylor devised his method of observing and recording elementary unit net times for performance with measured allowance for fatigue.

It is now possible to capture, record and transfer not only skill and experience of the best worker, but also the most desirable elements in the methods of all workers. To do this, scientific management carefully proceeds to isolate, analyze, measure, synthesize and standardize least wasteful elementary units of methods. This it does by motion study, time study and micro-motion study which are valuable aids to sort and retain all useful elements of best methods and to evolve from these a method worthy to be established as a standard and to be transferred and taught. Through this process is made possible the community conservation of measured details of experience which has revolutionized every industry that has availed itself of it.

Micro-motion study, presented for the first time at this meeting, is a new and accurate method of recording and transmitting skill. Based upon the principles of motion study and time study, it makes possible simultaneous measurement of both time and path of motions. It produces an entirely different result from any of the methods attempted by its predecessors, in that it shows a measured difference in the time of day on each and every cinematograph picture, even when the pictures are taken at a rate much faster than ever considered in work where positive films are printed and projected upon the screen.

The devices used in making micro-motion study are adaptable to the needs of the work. The kind of clock and camera used and the number of pictures taken per unit of time depends upon the nature of the work observed. For those interested primarily in the time study work of a machine shop, the clock that shows divisions of 1/200 of a minute is recommended; for ordinary problems of motion study, the clock showing divisions of 1/1000 of a minute is the best; and for those who desire to make the finest of motion and time studies for the purpose of obtaining ultimate methods of least waste, the clock showing divisions

of $\frac{1}{1,000,000}$ of an hour or less is absolutely necessary. Such a clock is essential for discovering the method of least waste in cases such as handing instruments to a surgeon when operating. There is no case in the industries where the necessity for highest possible speed consistent with desired results is so great. For example, when operating for mastoiditis, it is necessary that the probe to lift the scalp be used within the shortest possible time after the skin has been cut, before the blood has had time to run down into the cut. Micro-motion study and stereo-cycle graphs are the only methods that will measure the times and paths of different motion methods for doing this portion of the operation. Micro-motion study has already determined that the combining of two or more instruments or tools for such cases and reversing the ends in the hand is much quicker than dropping one tool and grasping another.

Not only is it possible with micro-motion study to make more accurate measurements of shorter times than one could with any other method of motion or time study, it is also less expensive, even for ordinary work, than the older stop-watch method. Much of the work can be done by a less skilful man than the old-time study man; moreover, provision is made for stopping all photographic expense during any time the worker is resting, or doing work where no record except elapsed time is wanted.

Recent improvements in the method of taking pictures and of using half-width films, with nearly twice as many pictures to the foot and about one-third as many to the second as is used in motion pictures of the standard "movies," have still further reduced the cost of taking micro-motion studies.

Because of the flexibility of the micro-motion study apparatus the possibilities of its use are much extended. It is possible to take pictures as slowly as is desired, for such observations for example, as are required on time study of the machine's time, such as one picture per minute, while when it is desired to study the minutia of motions the pictures can be recorded at any desired speed, even at the rate of 1,000,000 per hour, for short periods. Recording as it does rest periods as well as work periods, micro-motion study presents complete as well as accurate records of the skill displayed.

These records are not only indispensable to those who are to teach or transfer the skill or experience, are in themselves use-

ful as object lessons, but more important than all else they are the devices that measure and record the skill which is to be transferred. They are used by the man who makes standards to determine the most efficient method of doing work. By them he is able to "take any motion apart" and to think in elementary motions. Being provided not only with a record of the best method of the best man, but with records of the best methods of all most skilled workers, he can synthesize these into a standard method which will be better than any of the methods submitted, and is likely to be better than all combined.

To the worker this knowledge comes in various ways: He may be given photographic films depicting some method that he desires to acquire. These he can study at his leisure; making the demonstrator do the work as slowly as he pleases. The difficulty that most skilled workers find in making habitual motions slowly is a great hindrance to learning by observing them. The film records the swiftest motions, which can be taken apart and observed slowly. He may be given films on which are recorded methods of distant shops whose workers he would never otherwise observe. The worker may be taught not directly by the films, but by methods derived indirectly by them.

With records of skill that fulfil the three requirements of measurement, namely, (*a*) of proper units (*b*) made by scientifically derived methods (*c*) with devices that reduce expense, and with transference of skill that assures every worker an opportunity to acquire the best that has been thought and done in his line, scientific management can now look forward to fulfilling the ultimate demands, justify itself from the economic viewpoint, and reduce the cost of the product to the consumer.

Closure. The large amount of discussion offered on the report on The Present State of the Art of Industrial Management shows the interest in this subject on the part of members of the Society. This, and the manner in which the report was received, are sources of gratification to the committee. Although a few points were singled out for objection, the report as a whole seems to have been approved. In fact, these objections as they appear in the printed discussion, in most cases can be directly offset by quotations from the same source.

The first objection is that the report gives "no more than a fragmentary idea of the conditions under which this art is carried on in the United States today," first paragraph of Mr. Go-

ing's discussion. Offsetting this, we quote from the first paragraph of Mr. Gantt's discussion, " The committee have caught fully the present spirit of the movement now in progress, and Pars. 45 to 58 of their report seems to me to be an excellent resumé of the subject." It was obviously improper for the committee to consider the details of the systems of the art of management as practised, but it was essential to show the spirit of the movement and if possible the principles upon which it rests. This the report endeavored to do, and did do in the opinion of the member quoted above.

Mr. Thompson pointed out that there are several criticisms made by workmen against modern industrial management, and that labor unions are busily fighting its introduction. With further reference to these features is this sentence, " The report of such a committee as this should not have overlooked the opportunity to begin or extend the campaign of education in these particulars." And again, in regard to the dehumanizing effect on the workers of the methods of modern industrial management the same author says, " This committee must have had an opportunity to look into this side of the case; and it is to be regretted that they have not improved it more fully."

This author seems to have overlooked the necessity which compelled the committee to treat of their subject in a non-controversial manner. At the same time, the broad results from industrial management are clearly stated in Pars. 62 and 63. These seem sufficient to meet this criticism. In regard to the statement that the criticism of the dehumanizing effect should have been met, we need but quote from Mr. Coburn's discussion to show that the human side of the subject was found by one of the Society's members, " —the committee have expressed in their report the human interest side of scientific or labor-saving management, which some of its critics say it lacks." Further, the entire discussion of H. L. Gantt develops the point that the workers are benefited by the best of modern management.

The term, transference of skill, is used frequently in the report and conveys one of the important ideas in the definition of the new element in the art of management. This term seems to have been misinterpreted, for near the end of Mr. Thompson's discussion we read, " In this report the committee emphasize the ' transference of skill ' as the basic feature of the new labor-saving management. Unfortunately, however, it appears that

this term is used with two meanings. Throughout most of the report it seems to mean the accumulation of skill by the planning department and its transference from this department by actual instruction to the workmen just as machinery is said to be the transference of skill, according to the report, from the designer and draftsmen to the machine. The idea intended to be conveyed is undoubtedly right, but the illustration chosen is unfortunate;" and in Mr. Vaughan's discussion, "the transference of skill referred to in the report means in one place, doing away with skill, in another the improvement of skill, and develops into the idea of telling men how to do everything."

The idea of the "transference of skill" is abstract, and these quotations indicate that their authors have failed to get the meaning of the term as used by the committee. "Transference of skill" is a process, and the expression might be expanded into "the process of transferring skill." It was the completion of this process that did away with hand looms and hand weaving in England. At the time of this completion, the skill in hand weaving was the personal possession of the last generation of hand weavers. Men of the succeeding generation did not acquire this skill for there was no economic advantage in so doing. Yet cloth was woven in greater quantities than before, leading at once to the question, where then was the skill? It is evident that the yarn was being manipulated by machines, thus, the former human skill was now in the metal fingers and arms and levers of the mechanism. But a new form of human skill was being developed as the process advanced; this is, the practical ability to tend the machine, keep it in order and producing to its maximum capacity.

The report pointed out that this process had advanced to a great length in the field of machine design, but had remained almost without application in the field of manufacturing. The best of modern industrial management applies this process to all of the activities of manufacturing, that is, a study is made of the steps of manufacturing in the same way that a study is made of the steps of designing. The results of handling and operation study are recorded for the instruction of the men engaged in manufacturing, in the same manner that the conclusions of the study of design are recorded on drawings as instructions for what is to be made. The parallel is exact.

It must be emphasized that this process applies to much more

than the operation of machines, it applies to everything that is done in handling materials, machines, tools, and labor used in production. It is unnecessary to list these in detail, for everyone acquainted with manufacturing appreciates what is included. The training of the workmen is but one small, though important, part of the application of this process of transferring skill.

Regarding the discussion as a whole, there are two striking characteristics that attract and hold attention; the entire absence of exaggerated statement and the presence throughout of a humane spirit in keeping with the best trend of thought toward social justice. The first of these, the absence of exaggeration as to what industrial management has done or can do was to be expected in any discussion before a body of engineers. The second shows clearly the development that has taken place within the last few years leading to a new appreciation of the needs and rights of employees.

But this commendable attitude of justice does not seem to have had its full influence on the relations existing between management experts. Among some of these, there is an unfortunate spirit of intolerance. This is in marked contrast to the spirit prevailing in all the great divisions of engineering. In these there is room for the cadet engineer as well as the recognized expert and for many others between these two extremes possessing varied degrees of knowledge and experience, as witness the membership of our own Society. The same is true in the field of industrial management. There is room and need for everyone who understands the principles upon which it rests and who will conscientiously and intelligently apply them.

This situation and these facts should lead to a tolerant attitude between all who are honestly trying to further the art of industrial management, and there should exist the same spirit of mutual helpfulness and encouragement which actuates those in other lines of engineering specialization. On the other hand, all who are trying to exploit the present interest in this important subject for mere personal advantage must be unsparingly condemned.

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L. P. ALFORD, *Secretary*
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H. A. EVANS
W. L. LYALL
W. B. TARDY
H. R. TOWNE

Members Sub-Committee on Administration

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Attention is called to the table of equivalents for compound units. It is intended exclusively as a help to readers of foreign periodicals, and is considerably more complete than similar tables in the usual reference books.

THIS MONTH'S ARTICLES

Karpen's article on the planing flight of birds and Sée's on a new principle of longitudinal stability both contribute valuable new material to the still very young science of aeromechanics, the Sée principle of stabilization being of particular interest in that it may be immediately turned to practical purposes. In the new section, Farm Machinery, two types of power plows are described, a French and a German, with data as to cost of operation. The French type is interesting as an indication of the tendency to apply soil cultivation by mechanical power to small estates. An abstract in the section Internal-Combustion Engineering gives data on the cost of operating gasolene locomotives in mines in Belgium, as well as a brief discussion of the application of Diesel engines to driving locomotives, directly or with an electric power conversion. Neumann's article on thermal processes in a gas producer is of interest as it claims to be the first attempt to investigate the gas producer by determining the direction of thermal changes in it as a system subject to external influences. Hanffstengel, in the preliminary publication of his experiments on the power consumption of hoisting apparatus, discusses the bending resistance and breaking strength of chains, bending resistance of belts, scraper and conveyor worm efficiency, etc., which makes a welcome addition to the far from rich fund of the experimental data on hoisting machinery. Additional data on belts, by Kammerer, may also be mentioned in this connection. Particular attention is called to Leblanc's description

of automatic balancers, in view of the apparatus described as well as of the author's exposition of the theory of bodies rotating at high speeds. In the section Steam Engineering data may be found on the cost of permutit water purification. In the same section an abstract from an Italian periodical gives a detail discussion on the influence of cold air leaks on the efficiency of economizers, as well as a discussion of the Oddie-Simplex steam-air pump and Simplex valve gear. Attention of steam engineers is also directed to Daiber's article, in the next section, on stresses due to bending in lap riveted boiler seams indicating how such stresses can be determined graphically. A simple and efficient method for fireproof storage of drawings is described in the last section, Miscellanea, where may also be found data on melters' fever, production of moving pictures in factories, etc.; a brief discussion of scientific management and objections made to it by German labor papers closes the abstracts.

Aeronautics

On "Planing" Flight of Birds (*Sur le vol des oiseaux dit "vol à voile,"* V. Karpen. *Comptes rendus des séances de l'Académie des Sciences*, vol. 156, no. 10, p. 762, March 10, 1913. 2 pp. *t*). Investigation of conditions permitting planing flight of birds. The weight of the bird P in kg and the surface of wings S in qm are connected by the equation: $4\ S = P$. It is shown further, that in order to plane, the bird has to flow into the wind when the velocity of the latter decreases, and against the wind when it increases, and in order that the bird may maintain itself in the air without either descending or ascending, the velocity of the wind must *increase or decrease* at the rate of at least 0.30 m (0.98 ft.) per sec., if the direction of the wind is horizontal. If the wind has a vertical upward component, it tends to decrease the necessary minimum of the horizontal acceleration or deceleration. Generally, planing is possible whenever the average of geometric acceleration or deceleration is from 30 to 50 cm (0.98 to 1.6 ft.) per sec.

A New Principle of Longitudinal Stability of Aeroplanes (*Sur un nouveau principe de stabilité longitudinale des aéroplanes*, A. Sée. *Comptes rendus des séances de l'Académie des Sciences*, vol. 156, no. 8, p. 613, February 24, 1913. 2 pp. 1 fig. *et*). The usual principle of longitudinal stabilization is the so-called principle of longitudinal V, or the distribution of two fixed surfaces one behind the other, in a manner such that the front surface has a greater angle of incidence than the rear one (cp. *The Journal*, February 1913, p. 321). Instead of this, the author proposes the application of an entirely new principle, illustrated in Fig. 1. Let the aeroplane be composed of the main supporting plane A located behind the

plane B, the latter being free to rotate about the transversal axis C, and convex bottomwards, or generally of a shape such that the pressure of the air against it increases when the incidence decreases (there are S-shaped planes having this property as well as good supporting qualities). In motion, the plane B automatically takes a position such that the air pressure is taken up by the axis C, and the plane maintains a constant incidence. This is shown by Fig. 1. When the apparatus is in equilibrium, the two pressures D and E on the planes A and B have the resultant R passing through the center of gravity. If the apparatus dips forward, the angle of incidence of the two planes is decreased; the pressure D on plane A decreases, but the plane B immediately resumes its former incidence, and consequently the pressure E does not vary. The resultant of E and D therefore approaches E, and produces a couple which tends to relieve the bow of the apparatus, or to restore the original position. The same happens when the apparatus dips aft. The stabilizing action is greater than when the principle of longitudinal V is applied. To verify it experimentally, the author constructed a model of reduced dimensions which fully confirmed the theoretical expectations.

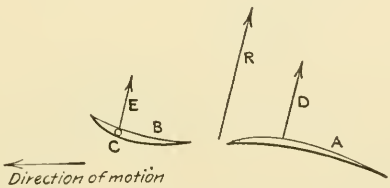

FIG. 1. SECOND SÉE PRINCIPLE OF LONGITUDINAL STABILIZATION OF AEROPLANES

Air Machinery

COMPRESSED AIR METERS AND DETERMINATION OF AIR CONSUMPTION (*Les compteurs d'air comprimé et l'évaluation de la consommation d'air*, W. Glucksmann. *Annales de l'association des ingénieurs sortis des écoles spéciales de Gand*, ser. 5, vol. 5, no. 4, 1912. 12 pp., 12 figs. *d*). General discussion of compressed air metering and description of the Hodgson compressed air meters. The article is based on the practice in South Africa where, in the mine fields, compressed air is produced in central stations and sold to subscribers like gas and electricity, necessitating reliable automatic meters.

MODERN STEEL PLANT GAS BLOWERS (*Neuere Stahlwerks-Gasgebläse*. Schomburg. *Die Fördertechnik*, vol. 6, no. 2, p. 38, February 1913. 2 pp. *as*). A general comparison of steam and gas blowers for steel plants, with tables showing the dimensions of the blowers of both kinds now in use, and lately ordered mainly for German plants, as well as the blower equipment of a large German steel plant. The gas blower shows an economy of 20 to 50 Pf. per ton (4.6 to 11.4 cents per short ton) raw steel.

For reserve power the older mills keep their steam engines, while more modern plants use either reciprocating or, more often, turbine steam drive. In one plant a tandem gas engine is used to supply the blast both to the blast furnaces and the steel making plant, thus providing for reserve power.

Farm Machinery

Latest Motor Plows (*Neuere Motorpfluge*, K. Praetorius. *Zeits. des mitteleuropäischen Motorwagen-Vereins*, vol. 12, no. 5, p. 107, Mid-March 1913, 6 pp., 15 figs. *d*. The article is to be continued). Description of some of the latest types of German motor plows. Fig. 2 shows the plow of the

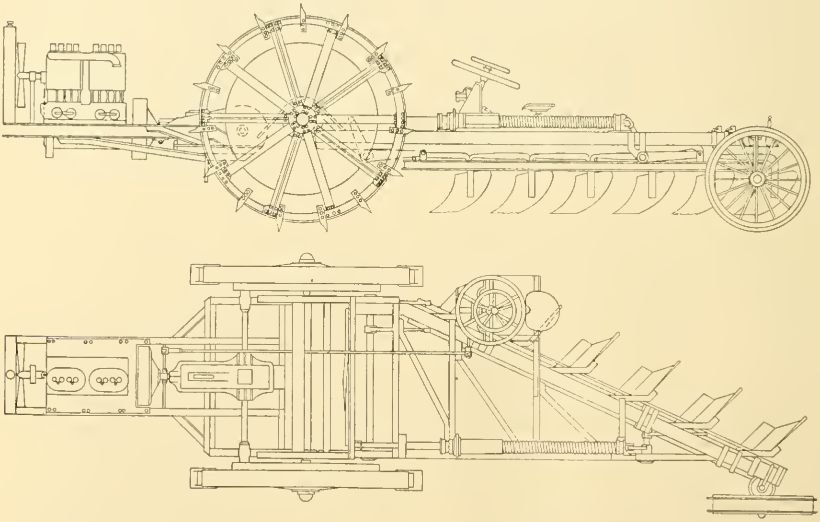

Fig. 2 Motor Plow of the German Power Plow Company

German Power Plow Co. (Deutsche Kraftpflug-Gesellschaft m.b.H.). It is a three-wheel type, with the two front wheels as drive wheels. The power transmission from the motor to the axle is by means of cone clutch over the differential gear. The plow frame is movably suspended on bell crank levers in a manner such that by rotating the screw spindle shown in Fig. 2, these bell crank levers can be displaced and thereby bring the plow frame to the ground either parallel or at a desired angle. This can be done from the driver's seat so that when an obstacle is encountered, the driver does not have to get up; at the same time, by means of a special spring arrangement, the frame is so balanced that the winding up of the screw spindle can be done without great exertion. The spikes on the wheel circumference have three vertical adjustments to suit various ground

conditions, and are of a shape such as easily to penetrate into the ground. By coming out in a nearly vertical direction, the amount of earth and clay adhering to them is minimum. The steering wheel is provided with sharp spikes, to find the necessary purchase in plowed over ground. When traveling along highways, a cover bandage is slipped over the wheels to pro-

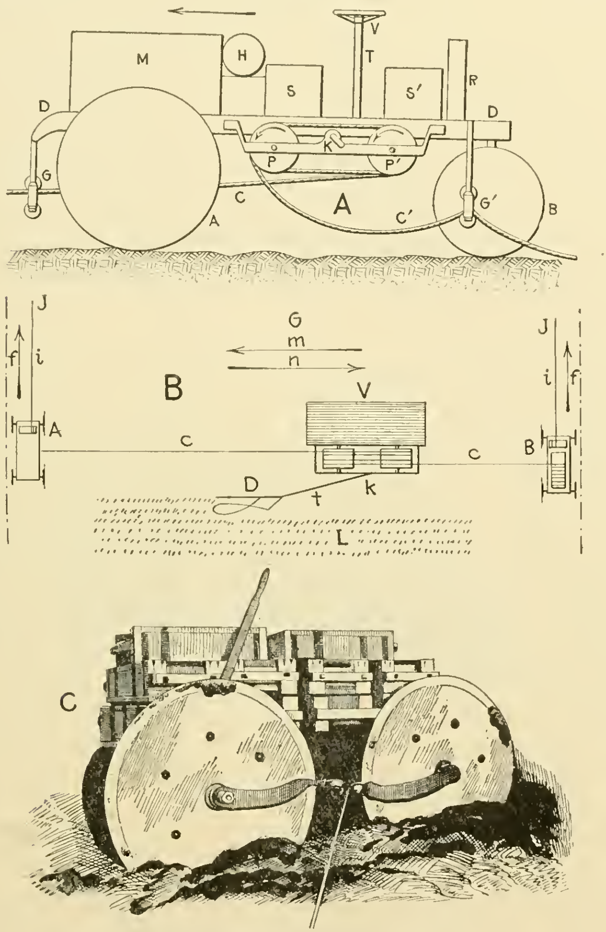

Fig. 3 Arion Towing Tractor

tect the spikes. The plow is driven by a 50-h.p. internal-combustion engine, and the operation cost per day, at the rate of 100 working days per year, plowing to a depth of 25 cm (say 10 in.) 20 Morgen (12.6 acres) per day, is at M.3.72 per Morgen ($1.43 per acre). No detailed cost data are given.

Towing Tractor Arion (*Le tracteur-toueur Arion*, Fernand de Condé. *Bulletin de la Société d'Encouragement pour l'industrie nationale*, vol. 119,

no. 1, p. 159. January 1913. 5 pp., 5 figs. *d*). The principle of the Arion tractor is the same as that of a towing boat. The tractor proper consists of a four-wheel carriage with a 30 to 40-h.p. explosion engine running at the normal speed of 450 r.p.m. On the side of the car body are two pulleys *P* and *P″* (Fig. 3 A), each with four grooves and means for connecting it with the engine. The plant (Fig. 3 B) is installed as follows: A stationary cable *c*, 15 mm (say 0.6 in.) in diameter, is stretched across the field between two anchors *A* and *B*, and coiled up on the pulleys *P* and *P″*; when these pulleys are set in rotation by the engine, they coil up the cable, and drive the vehicle towards, say, the point *B*, and the vehicle drags a plow or other implement after it. When the tractor reaches *B*, it is reversed, and goes back to *A*. The big wheels of the tractors are the running wheels, the small ones the driving wheels; the two-wheel trains run in different tracks, which permits the driving part of the cable *c* to pass between the big wheels, and *c′* to pass outside of the track of the small wheels, thus letting the cable run without interfering with the action of the wheels. Since the carriage moves first in one direction, and then in another, along parallel lines, it is provided with two seats for the driver *S* and *S′*, that he may face in the direction of motion; in order that he may always make the same motions for guiding the machine, the flywheel *V* and controlling rod of steering gear *T* are arranged so that they can engage with the driving chain either directly (one way) or by means of gears (when going the other way). The apparatus has no change speed gear; the flexibility of the engine which can run from 350 to 700 r.p.m. takes care of that. In addition to that, the speed of the displacement of the tractor may be varied by using different pulleys, say 30, 40, and 50 cm. (11.8, 15.7, and 19.6 in.) in diameter. Laterally the traction is effected by means of the chain *t* (Fig. 3 B). The tractor proper is of simple construction, and weighs only about 1500 kg, or about 3300 lb., practically the weight of two strong oxen.

There is however an important addition to it, viz., the anchor-cars (Fig. C); their frame is carried on four small wheels, with axles parallel to the direction of plowing. The two wheels on the side towards which the cable is stressed, are provided with sheet-iron discs of a diameter larger than the wheels, held against the spokes by bolts in a manner such as to form a spherical cap; this disc penetrates into the ground and, owing to its concave form, the tension of the cable tends to drive it deeper; to prevent the anchor-car from tilting sidewise. it is loaded with stones or pieces of iron, and the cable is attached as near the level of the ground as possible. At each operation the anchors have to be displaced in the direction of the shaft *f* (Fig. 3 B), a distance equal to the width of the furrow. The article indicates how this is done. Two men are required to operate the tractor, an engineer, and a man to take care of the anchors; two men, one at each of the anchors, are said to give still better results. Some data of tests are cited in the article.

Internal-Combustion Engineering

Two Years of Practice with Gasolene Locomotives (*Deux années de pratique avec locomotives à benzine*, A. Baijot. *Annales de mines de*

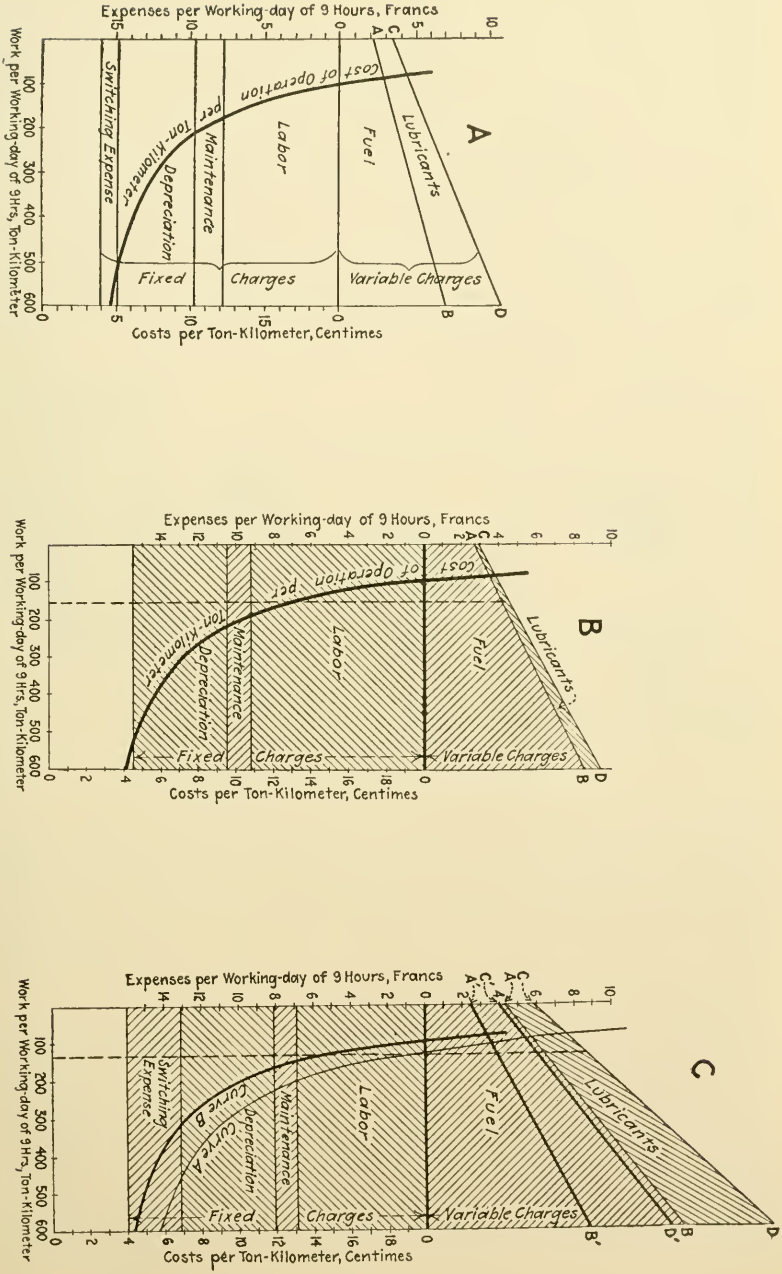

FIG. 4 GASOLENE MINE LOCOMOTIVE OPERATING COSTS IN BELGIUM

Belgique, vol. 18, no. 1, 1913, p. 3, 43 pp., 17 figs. *dp*). Data on Belgian practice of *gasolene mine locomotives*, of which the most important are presented in Fig. 4, 1 franc = \$0.193; 1 franc per ton-kilometer = \$0.282 per short ton-mile. The following conclusions can be drawn from these curves, at least as far as the Belgian practice is concerned: The fixed charges are the same nearly everywhere, and depend on the rate of wages, with a material increase in mines where switchmen are required; the variable charges are primarily functions of the cost of gasolene, the consumption being practically uniform in all cases. On the other hand, the consumption of oil and grease appears to vary considerably from plant to plant. In a general manner (Fig. 4 C) the curve of prices will be at *B* with price of gasolene at 18 frs. per 100 kg., but shifts to *A* when the price of gasolene rises to 32 frs. The most important fact which these curves show, however, is that the locomotives must be worked as hard as possible; with 400 to 500 ton-kilometers (275 to 340 ton-miles) in a 9-hour

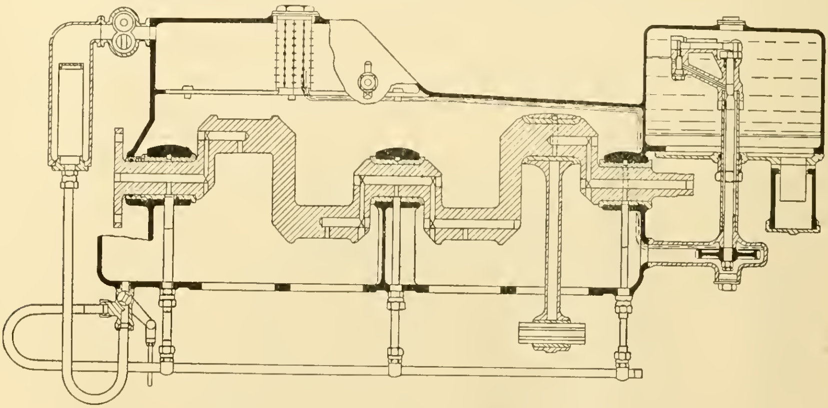

FIG. 5 NECKARSULMER CAR LUBRICATING SYSTEM

working day, the price per ton-kilometer is 5 to 7 centimes (\$0.013 to 0.018 per short ton-mile); often, however, only about 250 ton-kilometers per working day are made, in which case the cost rises to 8 to 11 centimes per ton-kilometer, and it goes up still higher when the work done per locomotive per day falls lower. On the whole gasolene locomotives in Belgium proved to be both economical and efficient, except in particular places where conditions are unusually unfavorable.

CAUSES AND EFFECTS OF PREMATURE IGNITION IN EXPLOSION AND COMBUSTION ENGINES (*Causes et effets des allumages prématurés dans les moteurs à explosion et à combustion. La Revue électrique*, vol. 19, no. 222, p. 270, March 21, 1913. 1½ pp. *p*). From a paper read by L. Letombe at a meeting of the Société des Ingénieurs Civil de France on February 7, 1913. General discussion of the causes of premature ignition. For a detailed abstract see *The Automobile*, April 10, 1913, p. 805.

DIESEL ENGINES AS MOTIVE PLANT FOR RAILWAY LOCOMOTIVES (*Dieselmotoren als Triebmaschinen für Eisenbahnfahrzeuge, Elektrische Kraft-*

betriebe und Bahnen, vol. 11, no. 4, p. 84, February 4, 1913. 1½ pp., 2 figs. *cd*). The advantages of the Diesel driven locomotive are: better use of fuel permitting an economy of 40 per cent against coal, even though the fuel itself costs nearly 240 per cent as much as coal; possibility of longer runs, and lighter fuel load on the engine. The direct-drive Diesel locomotive of Sulzer Bros. (for preliminary data of its construction cp. *The Journal*, June 1912, p. 942), according to the article, does not appear to have proved a success, mainly because direct-drive is little suitable for locomotive work. A large torque has to be exercised at the start at slow speed, and this calls for dimensions larger than would otherwise be necessary. On the other hand, Diesel electric locomotives are said to have been more efficient, since the engine can be driven at a high speed (direct-connected with the generator and exciter) and work at constant load. The article contains some brief data on the Diesel electric locomotive built for experimental and demonstration purposes by the Swedish General Electric Company in Västeras and operated on the Swedish State Railroads.

German Automobile Constructions (*Deutsche Automobil-Konstruktionen*, P. Fielehr. *Auto-Technik*, no. 6, p, 31, appended to *Allgemeine Automobil-Zeitung*, vol. 14, no. 11, March 14, 1913, serial, not complete. *d*). Description of some of the latest types of German automobiles. Fig. 5 shows the double lubricating system of the car of the Neckarsulmer Fahrzeugwerke A-G. In addition to the usual geared pump which provides lubrication for the bearings of the crankshaft, connecting-rod and piston pin, there is also a plunger pump which supplies oil to the crank case as it is used up in the engine. This second pump is placed inside an oil tank of proportions such as to provide oil for a run of 350 km (say 217 miles), and is driven from the camshaft by a worm and wormwheel. It has only one valve consisting of a ball pressed by a spring against the valve seat. The oil from the tank is sucked in through a hole in the pump casing, and part of it is forced out again until the piston in its downward stroke closes the opening; the oil remaining in the pump is then forced through the pressure valve along the pump shaft into the crank case, where it mixes with oil of circulation and is further taken care of by the geared pump. As shown in Fig. 5 it is impossible to shut off entirely the admission of the lubricant to the bearings, which therefore cannot run dry, even with careless operators; excessive lubrication may, however, be easily regulated.

The Processes in a Gas Producer from the Standpoint of the Second Law of Thermodynamics (*Die Vorgänge im Gasgenerator auf Grunde des zweiten Hauptsatzes der Thermodynamik*, Kurt Neumann. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 8 and 9, pp. 291 and 338, February 22 and March 1, 1913. 12 pp., 21 figs. *ctA*). An attempt to investigate the processes in a gas producer not on the usual principle of conservation of energy, but in accordance with the second law of thermodynamics, by determining the direction of changes in a system subject to external influences. The author claims that although several investigators have established the fact that the interaction between air and steam on one hand, and glowing coal on the other, leads, at certain temperatures, to

chemical equilibria, it is still an open question how near an approach to these equilibria is made in actual practice, and what are the most favorable conditions leading to the production of a gas of given composition. This is a complicated problem, because to determine gas reactions in a heterogeneous medium, measurements of pressure and temperature, as well as knowledge of the components of the gas phase, are required; in addition, the functional connection between the gas flow and time necessitates making these determinations in various layers of the producer and at several different points of each layer. Only the main deductions of the article can be given here. The author found that inside the coal column the water gas reaction, and in free gas space the carbon monoxide-carbon dioxide equilibrium are of fundamental importance. In the fuel bed the gas reactions are accelerated by the glowing coal, providing conditions in which the state of mutual equilibrium between the gases is easily established. In the free gas space there occurs a displacement of the gas phase until the velocity of reaction is reduced to such an extent that the gas acquires a composition corresponding to the given temperature. The equilibria limiting the chemical reactions in the gas producer are functions not only of pressures and temperatures, as would appear from the thermodynamic equations, but also, and to an essential extent, of time and constitution of the surface dividing the solid from the gaseous phase. This explains the variations in the composition of gas even in producers working under approximately similar conditions. Since in practical gas production operation the value of *all* the factors influencing the operation cannot always be fully determined, it becomes the more important to make a correct selection of at least those which can be so determined, and it is to be regretted that there is up to now no simple way of quantitatively regulating the composition of the gas in accordance with the amount of steam and air supplied. The loss of chemical energy in the final gas can be reduced by raising the gas velocity, that is, by a greater load on the producer; this method is however only partly efficient, since, with higher output, the temperatures in the fuel bed rise, and with them the velocity of reaction of the passage of gas through the dividing surface. On the other hand, by an application of a constantly cooled pipe, the time for cooling the gas may be reduced so as to permit a practically infinite velocity of gas flow, and reduce the loss to nearly zero. The loss can only be reduced, however, by endothermal reactions, and cannot be eliminated entirely.

Hoisting Apparatus

Experiments on the Power Consumption of Hoisting Apparatus (*Versuche über den Kraftverbrauch von Fördermitteln*, G. von Hanffstengel. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 12, p. 445, March 22, 1913, 9 pp., 29 figs. *eA*). Experiments to determine the power consumption of hoisting machinery, conditions influencing its magnitude, and methods for determining it, the last of particular importance, in the author's estimation, since it is of the greatest value to the practical engineer to be shown by what conditions the power consumption of hoisting machinery is affected; how to approximately determine the power consumption in usual

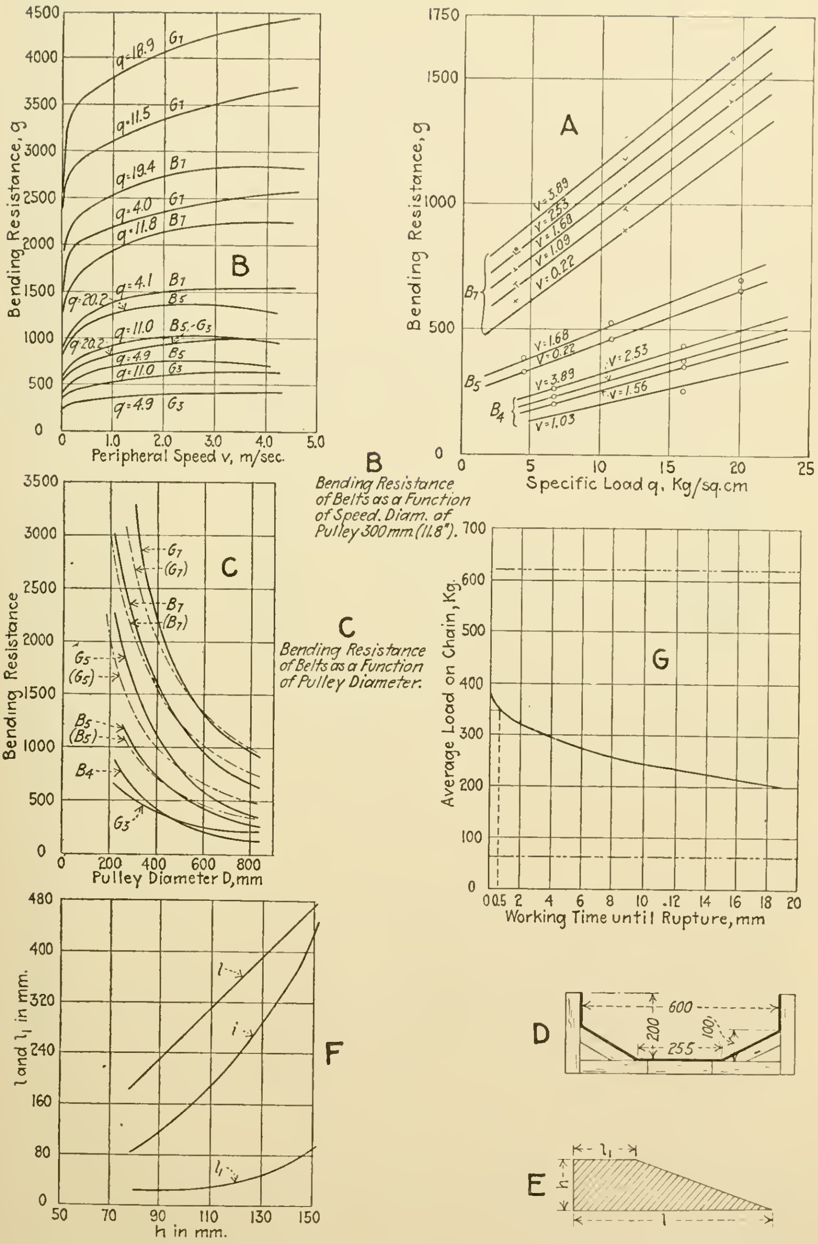

Fig. 6 Power Consumption of Hoisting Apparatus

cases, and how to go about obtaining the required data for the design of the more or less usual types. The several types and elements of hoisting machinery required all special tests to determine their influence on the power consumption; owing to lack of space, only the main data of this interesting investigation can be reproduced here.

Bending resistance of belts was measured for low velocities by placing the belt over a pulley the axis of which was free to roll on a smooth path; at both ends of the belt weights were placed, and the difference in the weights which started the motion of the pulley gave the bending resistance of the belt. A different arrangement, involving the use of two pulleys, was employed for higher speeds. Fig. 6 A shows the bending resistance of a belt 100 mm (3.9 in.) wide, for three balata belts B_4, B_5 and B_7, 5, 6 and 9 mm (0.196, 0.236 and 0.354 in.) thick, referred to specific loads in kg/qcm. In this case, as with nearly all other materials, the curves are straight lines. Fig. 6 B shows the bending resistance as a function of the speed, for the balata belts B_5 and B_7 and for a rubber belt G_5, 5 mm (0.196 in.), and G_7, 9.7 mm (0.38 in.), thick. The resistance increases rapidly at first, then slowly, and, in the case of the B_5 belt, decreases somewhat from a certain point. That the resistance is slight at low velocities can be explained by the assumption that the fibers have time to make room for each other, while at greater speeds the belt acts as a homogeneous body and has to be bent like a unit. As Fig. 6 C shows, with the increase in pulley diameter, the resistance decreases somewhat more rapidly than would be expected from an assumption of proportionality. This is shown in Fig. 6 C where the dotted lines indicate what the curve of bending resistance would have been under the law that resistance is inversely proportional to the diameter of pulley. The author shows also by means of curves the influence of the method of splicing belts on their bending resistance.

Bending resistance of chains. Their bending resistance proper, produced by the friction in the chain joints when running on and off the wheel, is expressed by the formula:

$$W_r = Q\mu\frac{d}{D}$$

where Q is the load on the wheel, or the sum of the tensions in the chain. It has been found however in these tests that μ is smaller for large chains than for small ones, and that the resistance generally increases with time of operation.

Scraper tests. A scraper trough, Fig. 6 D, of the American type was used, 4 m (13.1 ft.) long, covered with sheet iron on the inside. A carriage on wheels was driven over the trough, while a shovel ran through it. The experimental variables were: the material handled, width and cross-section of trough, shape of shovel, velocity of its displacement and degree of filling of the trough. It was found that the specific resistance referred to 1 kg of the material conveyed depended neither on the velocity nor degree of filling, but was materially (up to 10 per cent at least) affected by the shape of the shovel and trough. Inclining the shovel in the direction of motion made the resistance about 7 per cent higher than when the shovel was vertical; the American trough, Fig. 6 D, was found to be the most efficient. Tests were also made to determine the output of a scraping trans-

porter. The material conveyed, in this case coal dust, usually takes the form shown in Fig. 6 E in front of the shovel: the values of l_1 and l for different values of h have been determined, and together with calculated values of the volume of heap i plotted in Fig. 6 F.

Tests of a conveyor worm. It was found that the hardness of the material handled is here of primary importance, due evidently to the fact that the conveyor worm has either to push the stuff ahead, or break it.

The author has also fully investigated the extraction resistance in bucket elevators and the action of this type of apparatus, not reported here owing to lack of space. The following data found during the course of the investigation are of interest:

Coefficient of resistance of iron on smooth rail	0.16
Coefficient of resistance of iron on greased rail	0.12
Rolling friction	$f = 0.024$

Breaking strengths of chains at various speeds of operation. Fig. 6 G shows how long a Stotz driving chain at various loads lasted until ruptured, the speed being 3 m (9.8 ft.) per sec., the diameter of the wheel 500 mm (19.6 in.). For some special cases the author gives, in percentages, data

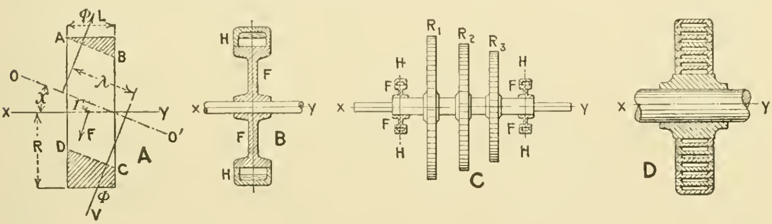

Fig. 7 Leblanc Automatic Balancer for High-Speed Rotors

on the material destroyed by handling in scraping transporters, bucket and worm conveyors. Full data of this investigation will be published in an early issue of the *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens.*

Machine Shop

Use of the Oxy-Hydrogen Flame under Water (*Verwendung der Wasserstoff-Sauerstoffflamme unter Wasser, Zeits für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 12, p. 143, March 21, 1913, 1 p., 2 figs. *d*). Description of an apparatus for cutting and welding metals under water. The flame is maintained under water by means of compressed air and a bell-shaped hollow extension screwed on to the usual oxy-hydrogen burner. No details of construction are given, but it is claimed that the working of the apparatus is fully satisfactory.

Mechanics

Automatic Balancers (*Equilibreues automatiques*, Maurice Leblanc, *La Lumière électrique*, ser. 2, vol. 21, no. 2, p. 35, January 11, 1913, 9 pp., 11 fig. *d*. Abstract of the second part of the article; for abstract of the first part see *The Journal*, March 1913, p. 533, particularly last paragraph on

p. 537). The author proves that possible jumps of a poorly balanced rotor may be counteracted by adding to it a perfectly balanced flywheel of sufficient mass. But with high-speed machinery it would be dangerous to make the flywheel of very large mass, running at very high peripheral speed.

Another solution has therefore to be looked for. Assuming that there is a flywheel, let it consist of a homogeneous disc limited by a cylinder of revolution about the axis xy of radius R on one hand and by two planes normal to this axis and at a distance L from each other (Fig. 7 A). Assume now a cylinder of revolution about the axis $00'$ through the interior of the flywheel and tangent to it at one of its edges. This cylinder and the flywheel have a solid body common to both and represented in section by the rectangle $ABCD$. This common solid has its center of gravity on the axis $00'$, and is consequently perfectly balanced about its axis of rotation; it can therefore be taken out without affecting the force F tending to reduce the distance between the axes xy and $00'$, and at the same time with materially decreasing the straightening-out couple $\Phi\lambda$. If only the first of these two effects is demanded from the flywheel, it can be hollowed out, leaving only the rim, or that portion the section of which is shown in cross-section in Fig. 7 A. The remaining mass μ is small in comparison with the mass M since the eccentricity e and angle α are always small in practice; it is the additional balancing mass. In order that it may produce the desired effect it must be distributed along the interior surface of the flywheel in a certain definite manner; on the inside it is limited by the surface of the level, and had it been a liquid inside of a hollow solid rotating about the axis of the figure xy, it would have become distributed of itself in the required manner under the action of the inertia forces developed by its rotation. The next step is to make it a hollow solid filled with mercury. On a shaft with axis of the figure xy (Fig. 7 B) is placed a small flywheel F provided with a shrunk ring H with a circular passage inside. Enough mercury to cover the exterior surface of the ring during its rotation about an axis other than the axis xy, but not enough to fill the passage up completely, is introduced into the passage through holes which are subsequently securely filled up. The height of the passage must be such that the mercury can never come in contact with the inner cylindrical surface of the ring during a displacement of the real axis of rotation. This represents an *automatic balancer* where the mercury acts as a supplementary *movable balancing mass;* mercury is used because with a small volume its mass may be made very large. Let R be the radius of the cylinder representing the exterior limit of the passage H; L distance between its limiting planes normal to the axis xy; δ density of mercury; g acceleration due to gravity. The shaft carrying the balancer is free to select its own axis of rotation, and if it happens to rotate about an axis passing at a distance ϵ from its axis of figure, the forces acting on the little mass of mercury have the same resultant as if they were acting on a disc full of mercury of radius R and width L. The balancer exerts therefore a force F tending to bring together the axes of the figure and that of rotation, and having for its expression

$$F = \pi R^2 L \frac{\delta}{g} \Omega^2 \epsilon$$

But, while the balancer is able to produce a very large force F, its straightening-out couple is comparatively small, and therefore instead of employing separately a force F and a straightening-out couple for bringing together the axis of the figure xy and the real axis of rotation of the rotor $00'$, two distinct forces F may be applied at the extremities of the axis of the figure xy, as shown, e. g., in Fig. 7 C. The author proceeds to show that the mass of mercury which has to be used is double that of a supplementary mass of a solid required to produce the same balancing, which is certainly very little, considering that the supplementary masses required are always small as compared with the masses of the apparatus to be balanced.

The author proceeds to analyze the case of a rotor which is not perfectly free to select its own axis of rotation, as is most often the case. In this case two groups of forces will act on the axis of the figure of the rotor: (a) forces limiting the displacement of this axis and tending to make it coincide with the axis of the figure of the stator inside of which the rotor revolves, and (b) dampening forces constantly opposing the displacement of points on the axis of the figure of the rotor to which they are applied, their direction being that of the velocity of the respective points, but the sense opposite. The author shows further that the elastic forces tending to make the axis of the figure of the rotor coincide with that of the stator will act in the same manner as the balancers; the dampening forces will tend to diminish the amplitude of the jumps of the rotor, and the distance ϵ will attain its maximum when the dampening forces become equal to zero. The action of the exterior forces will therefore tend to bring the axis of the figure of the rotor as near that of the stator as possible, or in other words, make the running as smooth as possible, but since these exterior forces, with the exception of the dampening forces, have their point of support on the brasses of the shaft, there is no advantage to be gained from making them artificially large.

Practical details of construction of automatic balancers. To reduce the amplitude of vibrations of the shaft of a rotor, the mass of mercury in the balancers must be spread on as large an area as possible, this being done by increasing the width L of the balancer passages (cp. Fig. 7 A). Since

$$m = 2\pi R \frac{\delta}{g} L\epsilon$$

and since further m and R are given, the product $L\epsilon$ is constant, and ϵ cannot be reduced without increasing L. A large area of passages, however, may be more conveniently obtained by superimposing a number of passages over each other as shown in Fig. 7 D, which permits making the balancer very powerful with slight volume and weight. This apparatus, scale $\frac{2}{9}$, if made of nickel steel, can run at 500 r.p.s. It must be remembered, however, that should the shaft get out of the axial position by 1 mm (0.039 in.) the push of the balancer to bring it back would be equal, as the author shows, to 3820 kg (8400 lb.), and with a greater deviation from the axial position, a correspondingly more powerful action. Should an accident happen, such as a rupture of a blade of a compressor, causing a large displacement of the shaft from the axial position, the reaction of the

balancer would be large enough to break the shaft. The only way to obviate that is to limit the action of the balancer apparatus to counteracting only a certain amount of shaft deviation, and this can be accomplished by giving to the tore with mercury a height ϵ corresponding to the maximum deviation of the shaft *when under normal conditions.* However, ϵ cannot be made too small or the annular layer of mercury would become too thin and surface tension phenomena too important, since the mercury would collect into drops and not spread uniformly as it should to bring it into perfect balance.

In the case of turbines with one wheel it is advisable to place the balancers near the rotor wheel, and not at the extremities of the shaft, which permits of counteracting the possible oscillatory movements at their very rise, and enables the speed of the blade wheel to be increased still further. The author discusses further the stability of the system of his balancer and the dampening of the oscillatory movements of the mercury mass, and proves among other things that in his experimental apparatus (cp. Fig. 7 D) which run at 500 r.p.s., the centrifugal force developed by the mercury mass was roughly equal to 34,000 times its weight.

TABLE 1 STRESS RATIOS IN BELTS

Kind of Belt	Mark	Stress Ratio ϵ	
		At Standstill	When Running
Link belt	FG 3	1.8	2 to 5
Link belt	FG 4	1.8	2 to 4
Greased leather	LR 2	1.5	3 to 4
Leather with grease removed	LR 16	2.5	2.3 to 2.4
Double belt	LR 10	1.2	3 to 6
Camel hair	KR 5	2.0	3.5 to 4.5

Geometrical Method Permitting the Establishment in a Simple Manner of Several Important Equations of Mechanics (*Méthode géometrique permettant d'établir simplement plusieurs équations importantes de mécanique*, G. Clauzel. *Revue de mécanique*, vol. 32, no. 2, p. 142, February 28, 1913, 27 pp., 16 figs. *m*). A strictly mathematical investigation, not suitable for abstracting in full. By investigating the properties of the axis of two vectors the author derives what he calls the fundamental equation of the projections of the vectors, and proves that by permutation of the indexes of the terms of these equations, the three equations for all three axes in space may be derived. These results are then generalized, and their application shown to such problem as the derivation of the moment of a vector; of the equations of the motion of a solid rotating around a fixed axis or a fixed point; the position of the central axis and the instantaneous sliding axis. The author uses the ordinary vectorial notation (not quaternions), and comparatively simple methods.

Experiments with Belts of Special Kind (*Versuche mit Riemen besonderer Art*, Kammerer. *Mitteilungen über Forschungsarbeiten auf dem*

Gebiete des Ingenieurwesens, no. 132, 1913, 73 pp., 98 figs. *cA*). Partly abstracted from a preliminary publication in *The Journal*, May 1912, p. 798. The author established in all cases of belt operation an excess of axial pressure, i. e., the axial pressure per unit (1 cm.) width of belt $2k_a$ was always larger than would be expected from the axial pressure $2k_v$ measured with the belt stationary. As seen in Fig. 8, in all cases the excess of pressure rises with the speed of the belt, nearly always in the same ratio, and only in the leather belts LR 11 and 14 the excess of pressure rises more rapidly than the speed. In the double belts LR 11, 12, 14 the excess of pressure, in kg per 1 cm width of belt, proved to be nearly double that of simple belts LR 15-45 and 16. In the case of woven belts KR5, and 65, *BaR* 67 and *BlR* 66 the excess of pressure proved to be variable, especially in the case of the camel-hair belts KR5 and 65. The maximum excess pressure was found with the link belts FG3 and 4.

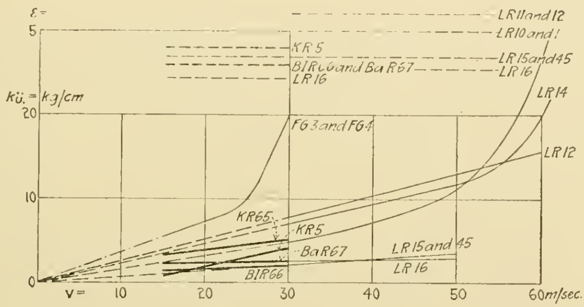

FIG. 8 EXCESS OF PRESSURE AND PRESSURE RATIO CURVES FOR BELTS

The pressure ratio of operation ϵ, or ratio between the stress at the tight and that at the loose side of belt, was found in nearly all cases (exception LR16) to be larger than the pressure ratio ϵ in friction test, the two ratios varying somewhat in different kinds of belts as shown by Table 1. Average values of ϵ are plotted in Fig. 8, which show that where the excess of pressure is high, the pressure ratio value is also high; this points to a probability of there being some connection between the two. The author discusses also the relation between permissible useful stresses and maximum useful stresses.

INVESTIGATION OF THE DYNAMICS OF A THREAD (*L. Roy, Annales de l'École Normale*, Ser. 3, vol. 29, pp. 371 to 429, through *Beiblätter zu den Annalen der Physik*, vol. 37, no. 5, p. 332. *t*). The author applied to the investigation of dynamic phenomena of threads the hydrodynamic theory of discontinuities, particularly discontinuities of the first order, and has thereby obtained general expressions for the propagation of longitudinal and transversal shocks in vibrating strings, as well as treated the problem of an oscillating string with the inclusion of the consideration of its viscosity. In the first chapter the general equations of the motion of strings are established, and conceptions analogous to those applied in hydrodynamics defined and expressed analytically in equations. Equations of continuity,

of motion and temperature are fully gone into. In the second chapter discontinuities are considered kinematically, both those of the first and of the higher orders, as well as their velocity of propagation, discontinuity itself being understood in the sense given to it by Duhem in his *Recherches sur l'hydrodynamique*, 1904. The next two chapters are devoted to a fuller investigation of discontinuities of the first and higher orders, while the last chapter is devoted to a discussion of small movements in threads, mainly near the region of stable equilibrium. It appears that in that case the equations admit of only one solution. Further, the case of a thread is considered as having one end fixed and the other performing a definite motion, and a particular solution was found for this case. The investigation of particular cases provides a means for experimental determination of the coefficient of viscosity. Cp. article by the same author in *Comptes Rendus*, vol. 152, pp. 1128 and 1743.

Steam Engineering

Investigation of a Positive Steam Engine Valve Gear with Respect to Mass Pressures (*Untersuchung einer zwangläufigen Dampfmaschinensteuerung auf Massendrücke*, O. Kölsch. *Dinglers polytechnisches Journal*, vol. 328, nos. 5 to 9, pp. 65, 88, 103, 118, 136, February 1 to March 1, 1913. 13 pp., 11 figs. *e*). Investigation of the slow-speed positive *Frikart valve gear*. It was found by graphodynamic methods that the journals are subjected only to slight pressures. The magnitude of the reaction moments on the steering shaft have been determined, both absolutely and in their functional relation to the time, and from the reaction moments-time curve it is shown by harmonic analysis that resonance can occur only when the natural frequency of the regulator "built in in the machine" is equal to the speed of rotation of the engine or a product of it by an integral.

Mestre System Squirrel Cage Superheater for Tubular Boilers (*Le surchauffeur en cage d'écureuil système Mestre, pour chaudières tubulaires*, P. Lachasse. *Revue Industrielle*, vol 44, no. 9, p. 113, March 1, 1913. 2 pp., 18 figs. *d*.). Description of the Mestre squirrel cage superheater as applied to locomotive boilers.

Permutit Iron Elimination Plant of the Wilhelmsburg Water Works (*Die Permutit-Enteisenungsanlage des Wasserwerkes Wilhelmsburg*, Hencke. *Journal für Gasbeleuchtung*, vol. 56, no. 10, p. 234, March 8, 1913. 1. p., 1 fig. *d*). From a paper read at the 14th annual meeting of the Gas and Water Engineering Society of Lower Saxony in Rendsburg (1912), containing data of the work of the permutit plant during one year. The water flows from the pumps through four permutit filters connected in parallel, potassium permanganate solution having been previously added to it. The filters consist of cylindrical vessels, 2 m (6.56 ft.) in diameter, and about 3.8 m (say 12.5 ft.) high; the water flows at a velocity of 20 m (65 ft.) per hour in a downward direction. Initially the water had a strong smell of hydrogen sulphide and a content of 0.56 mg of Fe_2O_3 per liter. The addition of potassium permanganate produced an evolution of oxygen which converted the hydrogen sulphide into sulphuric acid, and ferrous oxide into ferric. A layer of marble chips takes care of the free

carbon dioxide present in the water, while the permutit acts in the first place mechanically as a filter retaining the finely divided oxide of manganese and ferric oxide, and in the second place chemically, as a regulator of the supply of oxygen, either giving or taking it up in accordance as the potassium permanganate solution is either too strong or too weak.

In the quarter from July 1 to September 30, 1912, 176,707 cbm (6,237,500 cu. ft.) of water have been pumped, with iron content as above. The water finally obtained was free from all smells; 44 kg (say 97 lb.) of permanganate was used, costing M.35.64 (say $8.40). The permutit installation itself cost M.31,000 (say $7,440), while the piping involved an additional outlay of M.4,500 ($1,080). No further cost data are given in the article.

System of Piston Construction for the Prevention of Wearing Out-of-truth of Horizontal Steam Piston Cylinders (*Dispositifs de con-*

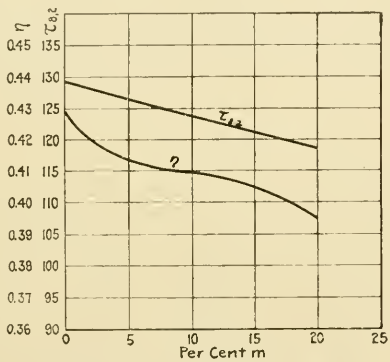

Fig. 9 Air Leak in Economizers

struction des pistons destinés à prévenir l'ovalisation des cylindres à vapeur horizontaux, O.-H. Wildt. *Revue de mécanique*, vol. 32, no. 2, p. 169, February 28, 1913. 7 pp., 8 figs. *dp.*). General description of the methods used for protecting the cylinders of horizontal engines from wearing out-of-true owing to the action of the piston. Leflaive & Co., of St. Etienne, France, have in their steam engines steel piston with a cast-iron belt in the lower part; the weight of the piston rests on this belt which also constitutes its wearing face, the advantage of this construction being in avoiding the rapid wear of the cylinder by friction of steel on cast iron.

On the Influence Exercised by Cold Air Leaks on the Efficiency of Economizers (*Sull'influenza che le chiamate d'aria fredda esercitano sul rendimento degli economizzatori*, G. Ghersina. *L'Industria*, vol. 27, no. 12, p. 179, March 23, 1913, 2 pp., 1 fig. *ct*). Investigation on the influence of air leaking, usually in considerable quantities, in economizers through openings in tube scrapers, cracks in walls, and in particular untight connections between the walls and the metallic parts of the economizer. Since in most cases the flow of the two fluids, hot gases and water, is at right angles to one another, the author assumes that in a section normal to the velocity of the flow of the hot

gases, their temperature is equal at every point, while the temperature of the water is assumed to be equal to the arithmetic average between those of entering and leaving water. This being assumed, let L_o be the length of the economizer measured positively in the direction of the velocity of the hot gases, S area of heat transmission per meter of length of economizer, A weight of water per hour passing through the same unit length of economizer with entering temperature t_1 and leaving t_2; G_o is the weight per hour of the hot gases (at temperature τ_o and specific heat at constant pressure c_o) passing from the furnace to the economizer, while G_1 is the weight of the air (temperature τ_1 and specific heat c_1) entering into the economizer through cracks from the section $L=0$ to $L=x$. In this case G_1 is a function of x and the weight of the gas passing through section $L=x$ is

$$G=G_o+G_1(x),$$

the amount of losses in the economizer evidently depending on the form of the $G_1(x)$ function, since, had all the air entered at $x=0$, it would lower the temperature of the entire mass of gases, and consequently decrease the amount of heat transmitted to the water; should it, on the other hand, enter at the other end, at $x=L_o$, it would not affect the efficiency of the economizer at all, though

TABLE 2 AIR LEAK IN ECONOMIZERS

m	0.00	0.05	0.10	0.15	0.20
g_o (kg/hr)	0	53.2	106.4	159.6	212.8
a	229	241.7	254.4	267.0	279.7
b	12520	12836	13153	13469	13786
p	0	12.7	25.4	27.1	50.7
$\tau_{8.2}$ (deg. cent.)	129.0	126.4	123.8	121.2	118.6
η per cent	42.9	41.3	40.9	40.4	39.5
t_2 (deg. cent.)	106.0	104.2	103.8	103.3	102.3

it might produce certain disturbances in the stack action. The author, however, considers only the case of air leaking in uniformly along the entire length of the economizer, so that

$$G_1(x)=\frac{x}{L_o}G_1(L_o)$$

or, with $\frac{G_1(L_o)}{L_o}=g_o$

$$G=G_o+g_ox$$

where g_o is the weight of air leaking in per hour per meter length of the economizer. He denotes by C the heat in calories lost per hour per meter of economizer length by radiation and convection, C being independent of x, and establishes the following heat balance for a section of the economizer comprised between two planes at a distance dx from one another. This heat balance is composed of the following heat values: (*a*) heat carried by the gaseous flow: $(G_oc_o+g_oc_1x)\tau$; (*b*) heat introduced with the water At_1dx; (*c*) heat coming from the air: $g_oc_1\tau_1dx$; (*d*) heat carried away by the gaseous flow: $[G_oc_o+g_oc_1(x+dx)]$ $(\tau+d\tau)$; (*e*) heat taken up from the water At_2dx; (*f*) heat Cdx lost by the length

dx of the economizer. The heat balance may be therefore expressed as follows:

$$(G_o c_o + g_o c_1 x)\,\tau + At_1 dx + g_o c_1 \tau_1 dx = [G_o c_o + g_o c_1 (x + dx)]\,(\tau + d\tau) + At_2 dx + Cdx$$

or, after certain simplifications, as

$$-(G_o c_o + g_o c_1 x) d\tau = [A(t_2 - t_1) + g_o c_1 (\tau - \tau_1) + C] dx \ldots\ldots\ldots\ldots [1]$$

A second equation is obtained by noting that through the area Sdx of a section of the economizer of length dx passes an amount of heat $A(t_2 - t_1)dx$, given an average difference of temperatures of the two fluids $\tau - \frac{t_1 + t_2}{2}$. With k as a coefficient of heat transmission that leads to the equation:

$$k\left(\tau - \frac{t_1 + t_2}{2}\right) Sdx = A(t_2 - t_1) dx \ldots\ldots\ldots\ldots [2]$$

which after certain simplifications and substitutions becomes

$$-\frac{1}{a}\frac{d(a\tau - b)}{a\tau - b} = \frac{1}{p}\frac{d(px + P)}{px + P} \ldots\ldots\ldots\ldots [3]$$

P and p being the weights, expressed in units of water, of the quantities G_o of hot gases and g_o of air. This equation integrated between the limits τ_o and τ and the corresponding zero values, gives

$$-\frac{1}{a}\log\frac{a\tau - b}{a\tau_o - b} = \frac{1}{p}\log\frac{px + P}{P} \ldots\ldots\ldots\ldots [4]$$

which solves the problem in permitting τ to be determined as a function of x and known quantities, and from this, by means of equation [2], temperature t_2 of leaving water, and finally efficiency of the economizer. If it be further assumed that there are no air leaks, or that $g_o = 0$, equation [3] becomes (integrated):

$$\frac{P}{a}\log\frac{a\tau' - b}{a\tau_o - b} = -x \ldots\ldots\ldots\ldots [5]$$

and from this and the preceding equation the difference $\tau' - \tau$, and consequently heat losses due to air leaks may be determined.

The following example is intended to show the use of these equations. A Green economizer has 224 tubes, 210 qm (2260 sq. ft.), with a length $L_o = 8.20$ m (26.8 ft.), thus making $S = 25.5$ mq. The total weight of water entering the economizer is 4669 kg (10,272 lb.), making $A = 569$ kg (1252 lb.), entering the economizer with a temperature of 60 deg. cent. (140 deg. cent.). The weight of the hot gases entering the economizer per hour is $G_o = 8730$ kg (19,206 lb.), with a temperature 234 deg. cent. (453.2 deg. fahr.), and specific heat at constant pressure $c_o = 0.245$. It is assumed further that the economizer loses by radiation per hour 10,000 calories (39,680 B.t.u.), which makes $C = 1220$ calories, or 4825 B.t.u., the coefficient of heat transmission is assumed to be $k = 11.0$. The temperature of outside air $\tau_1 = 25$ deg. cent. (77 deg. fahr.), and its specific heat $c_1 = 0.238$. Then:

$a = 229 + 0.238\, g_o$; $b = 12520 + 5.95\, g_o$; $P = 2140$; $p = 0.238\, g_o$.

Equation [5] becomes

$$\frac{2140}{22g}\, l_n \frac{22g\tau' - 12520}{41066} = -x$$

and for $x =$	0	2	4	6	8	8.2	
τ'	234	200	172	149	131	129	deg. cent.
τ'_{fahr}	453	392	341.6	300.2	267.8	264.2	deg. fahr.

The quantity of heat brought by the gases into the economizer is $Q_o = P\tau_o$, while that taken out is $Q' = P\tau'_{8\cdot 2}$; heat losses by radiation, etc., are CL_o. Consequently, $Q_o - Q' - CL_o$ is the heat passing into the water per hour, and the efficiency of the economizer is expressed by

$$\eta = \frac{Q_o - Q' - CL_o}{Q_o}$$

which, in no air leak operation is equal to $\eta' = 0.429$. Assume now that there are air leaks equal respectively to 5, 10, 15, 20 per cent of G_o, the weight of the hot gases entering the economizer. Then $g_o = m$, with $m = 0.05$, 0.10, 0.15, 0.20. Inserting the corresponding values of g_o into the respective expressions for a, b and p, and calculating only values of τ for $x = L_o$ (they are denoted by $\tau_{8\cdot 2}$) the values in Table 2 are obtained, for which compare also Fig. 9.

Oddie-Simplex Steam-Air Pumps (*Oddie-Simplex Dampf-Luftpumpe*, Prg. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 11, p. 434, March 15, 1913, 2 pp., 8 figs. *d*). Description of a new air pump, built by Maschinenfabrik Oddesse in Oschersleben, Germany. In addition to the usual bottom valve *a*, piston valve *b* and cover valve *c* (Fig. 10 A) it is provided with one or two supplementary suction valves *d* not balanced by springs, and therefore opening at very slight pressures, while the piston valve *b* is set to open only at 0.3 atmospheres pressure. Through the suction opening *e* steam, air, and water are admitted to the space under the piston, but only steam and air to that above the piston, so that the pump works as a combined dry and wet pump, the amount of air and steam admitted above the piston being the greater the later the piston valve *b* opens, or the lower the condenser pressure. In consequence, while in ordinary single-acting three-valve pumps the amount of steam and air handled decreases with improvement in vacuum, this is nearly entirely eliminated here by the second suction stroke on the upper side of the piston; the gain in active space, as compared with the single-acting air pump, may rise as high as 70 per cent, with a corresponding reduction in power consumption and space required for the same amount of work done.

Fig. B to F shows the general arrangement and details of the Simplex valve gear, with its main valve *f* displaced longitudinally by the steam pressure, and rotated about its longitudinal axis from the piston rod by the rod *g*. Over the ends of the slide valve are set caps *i* of which the slots *k* can be brought from outside against the slot *l* in the valve, and which is elastically connected with the valve-gear rod *m*, making the slide valve *f* lie in good contact with the glide face. The live steam enters the chambers *n* of the slide valve through the slots *k* and *l* by way of the throttling valve *o*, with considerably reduced pressure, because on its downward stroke the piston has to do less work than on the upward stroke. The valve is opened wide before the pump is started because the pump is full of water, but is gradually closed as the vacuum in the condenser rises until the pump works with equal speed on the upward and downward strokes of the piston. The slide-valve caps *i* are surrounded by steam all the time, and therefore cannot jam the slide-valve through unequal expansion.

In the position of the valve *f* shown in Fig. B, throttled live steam enters into the left slide-valve chamber *n*, and from there through the left pas-

sage p (Fig. F) to the upper side of the steam piston q (Fig. A), the exhaust r for the lower side being opened simultaneously. In addition through one of the small slots s (in this case the lower slot in Fig. F) and the duct corresponding to it, steam flows between the left outside surface of the slide-valve and the cap i, thus holding the slide-valve in its final position on the right. When the piston moves, the slide-valve is so rotated that the admission of steam is cut off at about 65 per cent of the stroke, and the piston completes its stroke under the action of the expanding steam. At the last moment of the stroke the valve is displaced back

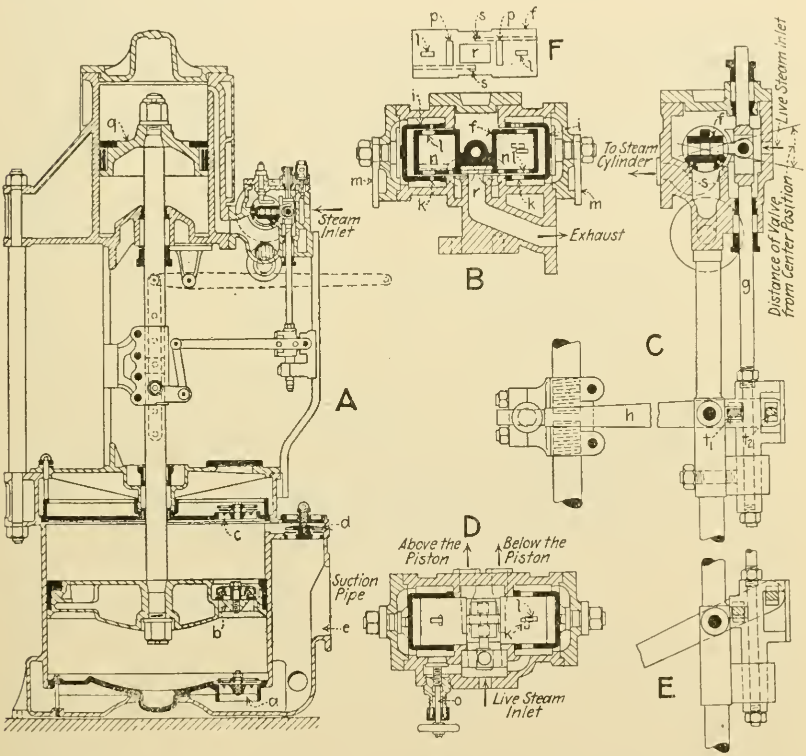

Fig. 10 Oddie-Simplex Steam Air Pump and Simplex Valve-Gear

in the longitudinal direction through the lower slot s coming in connection with the exhaust, and the upper with the live steam, which is thereby admitted between the valve and cap on the right side. Now live steam is admitted under the piston, and drives it upwards, the reverse motion occurring without shock because by this time the velocity of the piston is already considerably reduced by the expansion of the steam and the work done by the pump piston. As a rule, throttled steam, and not live, is used for the sake of economy in valve gears, throttled steam being admitted to the space above the slide-valve through s, Fig. F.

Strength of Materials and Materials of Construction

Waterproof and Airtight Fabrics (*Les tissus imperméables*, D. de Prat. *Le Génie Civil*, vol. 62, nos. 20 and 21, pp. 384 and 412, March 15 and 22, 1913, 6½ pp., 11 figs. *dg*). A somewhat general description of various processes used for making waterproof and airtight cloth, apparatus used in these processes and, briefly, methods of testing permeability of cloth to water and air. Data are given on the cloths used for the principal types of European dirigible airships.

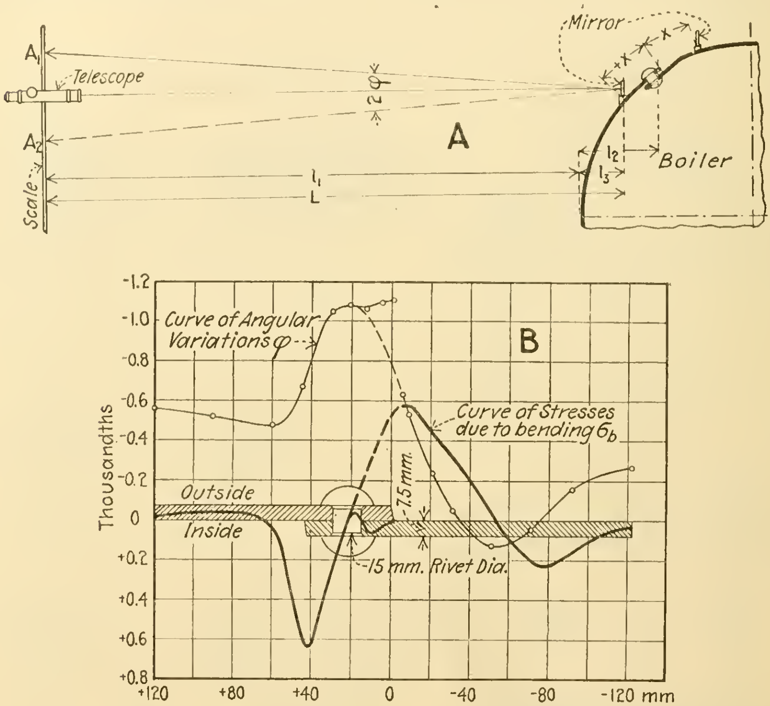

Fig. 11 Stresses due to Bending in Lap Riveted Boiler Seams

On the Influence of Cold-Working and Annealing on the Properties of Iron and Steel (*Über den Einfluss der mecanischen Formgebung auf die Eigenschaften von Eisen und Stahl*, P. Goerens. *Stahl und Eisen*, vol. 33, no. 11, p. 438, March 13, 1913, 7 pp., 12 figs. *ct*). Abstract of the first part of the author's article printed under the above title in the Carnegie Scholarship Memoirs of the Iron and Steel Institute, no. 3, 1911.

Corrosion and Rusting Tests of Sherardized Wrought Iron (*Korrosions und Röstungsversuche an sherardisiertem Schmiedeeisen*, Fr. Halla. *Zeits. für Elektrochemie*, vol. 19, no. 5, p. 221, March 1, 1913, 5 pp., 7 figs. *e*). Description and data of tests of properties of *sherardized wrought iron* made at the laboratory of the Royal Bureau for the Promotion of In-

dustry. The relation between the thickness of the layer of zinc and conditions of test in the case of wrought iron was investigated, as well as the speed of corrosion, the latter being expressed in curves. As to phenomena of rusting, it was found that with samples of sherardized wrought iron placed in water, white flocks of zinc hydroxide formed after one day, which very soon began to assume a yellowish color, thus showing the beginning of the process of iron rusting. Deep rusting took place, however, only where the layer of zinc was particularly thin, or when two iron pieces came in contact, so that, on the whole, sharardization seems to protect the iron from rusting.

Stresses Due to Bending in Lap Riveted Boiler Seams (*Die Biegungsspannungen in überlappten Kesselnietnähten*. E. Daiber. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 11, p. 401, March 15, 1913, 6 pp., 10 figs. *c*). Data of tests of stresses due to bending in lap-riveted boiler seams, and discussion of a method for the determination of these stresses, as well as of the main factors determining their magnitude. The tests were made on eight boilers. The stresses investigated were determined by finding the angle variation φ of the boiler shell when the boiler was subjected to pressure.

To do this, little mirrors were placed at different points on the circumference of the boiler (Fig. 11 A) and the variation of their position determined in the usual manner by a telescope and scale. The mirrors were attached to a boiler shell by wax, which proved to be the best material to be used for this purpose, and for purposes of measurement the middle of the wax piece, 5 to 6 mm (0.19 to 0.23 in.) wide was considered. Cold pressure produced by an ordinary hand pump was applied, in one case three pressure stages 2 to 6, 6 to 10, and 10 to 14, atmospheres, but as it was found that the angular variation of the mirror was proportional to the pressure, the other tests were carried out with one pressure only, at least as high as the working pressure for the given boiler. No residual angular variations were observed, this probably being due to the fact that the boilers had previously been under pressure.

The first test was made with a small locomotive boiler, 600 mm. (23.6 in.) in diameter, with walls 7.5 mm. (0.3 in.) thick, and a single riveted seam about 1500 mm. (say 60 in.) long. The angular variations were determined between the initial pressure of 5.3 and final pressure of 10.5 atmospheres absolute. The following dimensions were determined (Fig. A): $l_1 = 6140$ mm., $l_2 = 220$ mm.; hence for the point $x = 90$ mm. distant from the lap edge; $l_3 = 130$ mm. and $L = l_1 + l_3 = 6279$ mm. For the same point the following telescope readings have been made:

At initial pressure of 5.3 atmospheres .... $A_1 = 10.30$
With pressure raised to 10.5 atmospheres .... $A_2 = 10.17$
With pressure reduced to 5.3 atmospheres .... $A_3 = 10.30 = A_1$

Showing an elastic variation corresponding to the difference of readings $\triangle A = A_2 - A_1 = -0.13$. The unit of the scale used was 5 cm. long, and the angular variation was therefore:

$$\left.\begin{aligned}\varphi&=\frac{5\triangle A}{2L}=\frac{\triangle A}{0.4L}\\ \varphi&=\frac{-0.13}{251}=-\frac{0.52}{1000}\end{aligned}\right\}\qquad\text{or numerically}\qquad[1]$$

The angular variations φ are shown in Fig. 11 B (numerical values are given also in a table in the original) as ordinates, with x (cp. Fig. 11 A) as abscissae, and a smooth curve drawn through the φ points showing the bending moments at each point of the boiler shell. From the differential equation of this line,

$$\frac{d^2y}{dx^2}=\frac{d\varphi}{dx}=\frac{xM_b}{\Theta}\quad\text{.........}[2]$$

is derived the expression for the bending moment

$$M_b=\frac{\Theta}{a}\frac{d\varphi}{dx}\quad\text{.........}[3]$$

Where a is the coefficient of elongation of the material, and Θ the moment of inertia of the boiler shell from which a strip 1 cm wide is cut out; hence:

$$\Theta=\frac{s}{12}\quad\text{.........}[4]$$

where s is the thickness of the wall. The stresses due to bending in the outside fibers, and corresponding to a given moment, are therefore,

$$\sigma_b=\frac{s}{2}\frac{M_b}{\Theta}=\frac{s}{2a}\frac{d\varphi}{dx}\quad\text{.........}[5]$$

It appears from equations [3] and [5] that both the bending moments M_b and the maximum stresses due to bending σ_b at any point (x,O) are proportional to the angle $\frac{d\varphi}{dx}$ of the tangent at (x,φ) and the curve of angular variations φ. Information as to the magnitude and distribution of stresses due to bending in the neighborhood of a lap-riveted joint may therefore be obtained graphically by drawing at various points tangents to the curve of angular variations φ, determining their inclination with due regard to the scale used, and multiplying the figures obtained by the constant $\frac{s}{2a}$. This method gives only stresses due to bending when the pressure is varied from 5.3 to 10.5 atmospheres but the author gives a method for reducing these data to any pressure whatever. He shows also that the shearing stresses occurring in these cases are of but little importance in the total stress on the material. With regard to Fig. 11 B attention is called to the fact that the curve of stresses due to bending σ_b is drawn on that side of the figure of the boiler sheet in which at bending a tensile stress was produced.

The second part of the article, an analytical method for the calculation of stresses due to bending, can not be abstracted here owing to lack of space.

Miscellanea

The Production of Moving Pictures in Factories (*Die Herstellung kinematographischer Bilder in Fabriken*, G. A. Fritze. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 12, p. 454, March 22, 1913. 7 pp., 10 figs. *d*). Moving pictures of factory processes have, in addition to their educational value, also an advertising value, and act as silent but eloquent salesmen, in giving outsiders an idea of the size and capacity of the plant represented. The pictures should be taken and films made by a concern that makes a business of it, rather than by home means, and the price for a 250 m (820 ft.) film need not exceed M.1000 (say $240). The author discusses fully the best system of lighting for making such photographs,

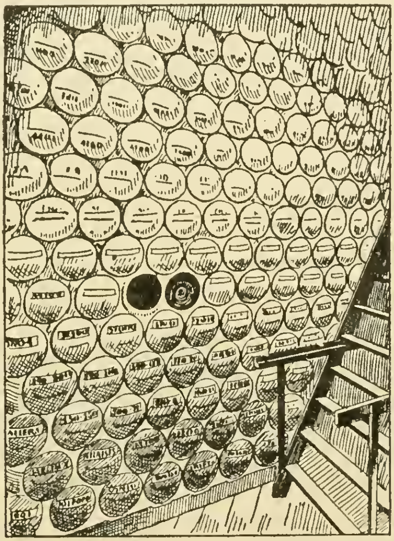

Fig. 12 Fireproof Storage of Drawings

position of apparatus, and similar phototechnical details. (The method is entirely different from that of Thomas A. Edison who makes his films from technical processes not from the actual shop processes, but from specially prepared models; e.g., the Bessemer converter films are made with a glass model of a converter, and colored ink instead of molten steel.)

Melters' Fever (*La fièvre des fondeurs*, *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, vol. 119, no. 2, p. 322, February 1913. *g*). Abstract of an article in *Annales d'hygiène*, January 1913, pp. 82-93, by L. Bargeron. After investigating a large number of cases of diseases of metal melters, the author concludes that fumes of copper in themselves are practically harmless, and that what is known as melters' fever is due to fumes of oxide of zinc exclusively. These fumes produce in the organism a kind of temporary intoxication, and their action may be aggravated by alcoholism or diseases of kidneys or liver. The disease is not considered

to have usually grave consequences, and may be entirely eliminated by simple hygienic precautions, of which the best is good ventilation.

Progress in Wind Motors (*Le progrès des moteurs à vent, L'Electricien*, ser. 2, vol. 45, no. 1160, p. 184, March 22, 1913, 1 p., 6 figs. *d*). A brief description of wind motor types, including that of the Turnbull aeromotor recently shown at an exhibition in Sydney, Australia.

Fireproof storage of drawings (*Procédé de préservation des plans et dessins industriels contre l'incèndie*, B. Beaussart. *Revue industrielle*, vol. 44, no. 12, p. 155, March 22, 1913. *d*). Description of the plan of storing drawings adopted by Bollinckx. In this concern all the drawings are made on tracing cloth from which blueprints are made when required. The tracing cloth drawings have therefore to be stored. All are of uniform dimensions, 0.80 m by 1.20 m (say 31.4 in. by 48 in.). Each drawing is put into a clay tube which in its turn is placed into an appropriate opening in a concrete wall (Fig. 12). Each tube is slanted towards the front, so that should any water penetrate into it, it would not stay there; there is however little chance of that because each tube is provided with a stamped sheet-iron cover on the top. In the ilustration is shown a ladder for reaching the upper layers of drawings. This system proved to be remarkably convenient; it has been used for four years, and the drawings keep in perfect condition, due probably to the constant temperature in the concrete structure.

F. W. Taylor's Principles of Scientific Management for Concerns of All Kinds (*F. W. Taylor's Grundsätze methodischer Anleitung bei Arbeitsvorgängen jeder Art*, F. Neuhaus. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 10, p. 367, March 8, 1913, 4 pp. *d*). With the growth of industry in Germany, as everywhere else, the supply of labor could not follow the demand, and the wages rose more and more. This naturally led to means for reducing the cost of production, and the last ten or fifteen years have witnessed an intense activity in equipping the shops with *labor-saving devices, automatic machinery*, etc. But, except in some of the largest plants, the introduction of *labor-saving systems of management* have been retarded in Germany mainly on account of the large expense, time and attention which they require as compared with the introduction of automatic machinery alone.

The rest of the article contains an exposition of the Taylor system of scientific management in accordance with Mr. Taylor's own writings. As regards German conditions, the author states that as far as practical application of the principles of scientific management is concerned, there is little new in it, and some exceptionally efficient men, particularly in the large works, have used it more or less for years, but it was not systematized and done on a definitely accepted plan, so that often, when the particular manager left the works, things were apt to drift back into the usual routine. The Taylor system does not by any means eliminate the importance of the manager's personality, but makes possible a systematic effort towards raising *the efficiency of the plant*. The *German labor papers* appear to have already taken a stand against scientific management. Their main objec-

tions are that it makes of the workman a machine, or, as one paper expressed it, a "beast of burden," to which the author replies that there is really more monotony in the usual occupations than there is likely to be under scientific management, with the additional advantage of the latter that under it there is more chance for the workman to be placed at a congenial kind of work than when the management takes no systematic interest in what each man is doing. The second objection is that it is unjust not to give the laborer the full benefit of his increased production. The author's arguments are that hitherto the plant and tools have not usually been fully utilized, and that the workman is not required under the new system to work either longer or with more effort, but simply by better and more productive methods, found by scientific study of the process; further, that the workman himself did not contribute anything to this increased production, which is due mainly to the labor and expense on the part of the management, and that even if the workman does not get an increase in wages commensurate with the increase in production, the nation is fully benefited thereby.

COMPOUND UNITS

Symbols	Continental Units	American Equivalents	Logarithms of Factors of Equivalence
gr/cm	gram per centimeter	0.0055 lb. per in.	$\bar{3}.74816$
kg/m	kilogram per meter	0.055 lb. per in.	$\bar{2}.74816$
kg/km	kilogram per kilometer	3.54 lb. per mile	0.54900
kg/qcm	kilogram per square centimeter	14.22 lb. per sq. in.	1.15300
kg/ha	kilogram per hectar	0.89 lb. per acre	$\bar{1}.94939$
kg/Morgen	kilogram per Morgen	3.49 lb. per acre	0.54282
t/m^2	metric ton per square meter	0.102 short tons per sq. ft.	$\bar{1}.01033$
kg/m^3	kilogram per cubic meter	0.062 lb. per cu. ft.	$\bar{2}.79518$
kg/hl	kilogram per hectoliter	0.083 lb. per gallon	$\bar{2}.91907$
t/m^3	metric ton per cubic meter	62.4 lb. per cu. ft.	1.79518
kg/h.p.	kilogram per Continental horsepower	2.23 lb. per American h.p.	0.34830
kg/t	kilogram per metric ton	2 lb. per short ton	0.30103
kgm/kg	kilogram-meter per kilogram	3.28 ft.-lb. per lb.	0.51587
kgm/qcm	kilogram-meter per square centimeter	46.58 ft.-lb. per sq. in.	1.66819
t/km	metric ton per kilometer	1.77 short tons per mile	0.24797
t–km	metric ton-kilometer	0.6849 short ton-miles	$\bar{1}.83562$
Costs			
Fr/m	Franc per meter	0.058 cents per ft.	$\bar{2}.76342$
M/m	Mark per meter	0.072 cents per ft.	$\bar{2}.85733$
Fr/t	Franc per metric ton	$0.175 per short ton	$\bar{1}.24303$

COMPOUND UNITS—*Continued*

M/t	Mark per metric ton	\$0.216 per short ton	$\bar{1}.33445$
Fr/qm	Franc per square meter	\$0.018 per sq. ft.	$\bar{2}.25527$
M/qm	Mark per square meter	\$0.022 per sq. ft.	$\bar{2}.34242$
Fr/cbm	Franc per cubic meter	\$0.0054 per cu. ft.	$\bar{3}.73239$
M/cbm	Mark per cubic meter	\$0.0067 per cu. ft.	$\bar{3}.82607$
Fr/ha	Franc per hectar	\$0.078 per acre	$\bar{2}.89209$
M/Morgen	Mark per Morgen	\$0.36 per acre	$\bar{1}.55630$
Fr/h.p.	Franc per Continental horse-power	\$0.195 per American h.p.	$\bar{1}.29003$
M/h.p.	Mark per Continental horse-power	\$0.241 per American h.p.	$\bar{1}.38201$
Fr/Cal	Franc per calorie	\$0.048 per B.t.u.	$\bar{2}.68124$
M/WE	Mark per Wärmeeinheit	\$0.060 per B.t.u.	$\bar{2}.77815$
Fr/t-km	Franc per ton-kilometer	\$0.281 per short ton-mile	$\bar{1}.44870$
M/t-km	Mark per ton-kilometer	\$0.347 per short ton-mile	$\bar{1}.54032$
Fr/kg	Franc per kilogram	\$0.087 per lb.	$\bar{2}.93951$
M/kg	Mark per kilogram	\$0.108 per lb.	$\bar{1}.03342$

HEAT UNITS

Calorie	=WE (Wärmeeinheit)	3.968 B.t.u.	0.59857
C/kg	Calorie per kilogram	1.80 B.t.u. per lb.	0.25527
WE/kg	Wärmeeinheit per kilogram	1.80 B.t.u. per lb.	0.25527
C/qm	Calorie per square meter	0.368 B.t.u. per sq. ft.	$\bar{1}.56584$
WE/qm	Wärmeeinheit per square meter	0.368 B.t.u. per sq. ft.	$\bar{1}.56584$
C/cbm	Calorie per cubic meter	0.112 B.t.u. per cu. ft.	$\bar{1}.04921$
WE/cbm	Wärmeeinheit per cubic meter	0.112 B.t.u. per cu. ft.	$\bar{1}.04921$

REPORTS OF MEETINGS

ST. LOUIS MEETING, MARCH 19

At a meeting of the Associated Engineering Societies of St. Louis, in charge of the local committee of The American Society of Mechanical Engineers, on March 19, Prof. Wm. Kent gave an address on Engineering and Common Sense. Over 100 engineers were in attendance. A dinner in honor of Professor Kent preceded the meeting.

BOSTON MEETING, MARCH 25

A meeting of the Society was held in Boston on Tuesday evening, March 25, Henry Bartlett of the local committee presiding. The principal paper of the evening was by Frank W. Reynolds, Mem. Am. Soc. M. E., on the Modern Cotton Mill. Mr. Reynolds discussed the general conditions controlling the site and layout of a standard cotton mill, including the determination of the spaces to be assigned to different departments, their relative location, the handling of material and product, distribution of power, illumination, etc., and the types of building best adapted to housing the several parts of the plant, together with the principal details of their construction. He presented a number of views illustrating these general principles as well as details of special interest.

This was followed by a brief paper on Lighting of Mills, by Albert L. Pearson, Mem. Am. Soc. M. E., in which he discussed the best form of distribution of artificial illuminants, pointing out the special conditions to which each type and size of light was best adapted.

Fred W. Parks, president of the G. M. Parks Company of Fitchburg, Mass., presented a short paper on Air Conditioning for Textile Mills, in which he quoted the results of extended inquiries, showing the practical value of a proper system of humidifiers, and also giving interesting information in regard to heating and ventilation as applied to mills.

These papers were followed by an extended discussion, participated in by F. W. Dean, W. G. Bartlett, A. L. Williston, E. D. Lyle, R. A. Hale, F. M. Gunby, and others, which brought out much further information.

PROVIDENCE DINNER, APRIL 10

The annual meeting and dinner of the Society and the Providence Association of Mechanical Engineers was held at the Crown Hotel, Providence, on the evening of April 10, preceded by a reception in the parlors of the hotel. About 100 members and guests were in attendance.

Prof. T. M. Phetteplace, Mem. Am. Soc. M. E., president of the Providence Association, gave the address of welcome and introduced the toastmaster, William H. Paine. Calvin W. Rice, Secretary of the Society, spoke on the advantage of coöperation among engineers and what is being done

to promote it and Prof. W. H. Kenerson, Mem. Am. Soc. M. E., spoke on the relations of the two organizations represented. Prof. Charles F. Scott, Mem. Am. Soc. M. E., of Yale University was the principal speaker of the evening, taking as his topic the Future of the Engineer. Letters of regret were received from Governor Pothier, Mayor Gainer, Professor Goss and Professor Everett.

NEW YORK MEETING, APRIL 4

An exhibition of the kinetophone and of the latest improvements in the field of moving pictures and sound production was presented on April 4 in the Engineering Societies Building, New York, before the members of the three founder societies, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, through the courtesy of Mr. Thomas A. Edison, Hon. Mem. Am. Soc. M. E., and of the American Talking Moving Picture Company.

John W. Lieb, Jr., Mem. Am. Soc. M. E., presided over the meeting and the necessary explanations of the apparatus displayed were made by Miller Reese Hutchinson, Mem. Am. Soc. M. E., chief engineer of the Edison Laboratory.

A presentation of the proposed application of the moving picture to educational systems was first made, showing Mr. Edison's plan of revolutionizing the teaching of such subjects as geography, natural science, applied arts, and all those in which the phenomena or objects described can not be shown to the pupils. Where descriptions or illustrations from a text book are now necessary, pictures showing the object itself will be used, thus appealing to the child through the most responsive faculty of youth, that of vision. In illustration of this, there were shown on the screen various kinds of pumps, the action of a magnet and an electromagnet, the mutual arrangements of floating magnets in a supporting but non-magnetic medium, the formation of crystals, and certain natural history phenomena, and it was evident that these pictures contained elements of interest even to those fully familiar with the objects presented, who had probably worked out many of the results in their laboratories and designing rooms.

The kinetophone or talking moving picture machine, Mr. Edison's latest invention to be put upon the market, was then demonstrated. The moving pictures and phonograph were shown to be in perfect synchronism, producing a remarkable illusion. While the principle of the action of the apparatus has not yet been made public, it is easy to see the importance of its application not only for purposes of amusement, but also for investigations of a scientific character, in acoustics, machinery noises, air compressor action, disruptive spark phenomena, etc.

NEW HAVEN MEETING, APRIL 16

A meeting of the Society was held in New Haven in the Mason Laboratory of Mechanical Engineering on April 16, with afternoon and evening sessions. E. S. Cooley, chairman of the New Haven local committee, presided at the afternoon session. Papers were presented on General Types of Heating Systems, by Allen C. Staley of the mechanical engineering department of the Sheffield Scientific School, describing various apparatus

with the aid of a profusion of lantern slides; and on the Heating, Ventilating and Humidifying of the Cheney Brothers Silk Mills, by G. H. Miller, Mem. Am. Soc. M. E., in which the automatic system for maintaining constant temperature and humidity day and night the year around in some of the mills of the company, was described. These papers were discussed by W. G. Snow, Mem. Am. Soc. M. E.; R. W. Pryor, Jr., Jun. Am. Soc. M. E.; T. A. Donnely, of the Positive Differential Company; W. F. Goodenough, of the American Radiator Company; Calvin W. Rice, Secretary of the Society; Prof. L. P. Breckenridge, Mem. Am. Soc. M. E.; Frank B. Gilbreth, Mem. Am. Soc. M. E.; and W. J. Baldwin, Mem. Am. Soc. M. E.

An intermission was given at five o'clock for the inspection of new apparatus in the laboratory for experiments of heating boilers and fans. Dinner was served at six o'clock in the Yale Dining Club.

The evening session opened at 7.30 p.m., Prof. Chas. F. Scott, Mem. Am. Soc. M. E., presiding. Greetings from the Society were extended by the Secretary, Calvin W. Rice, and Professor Scott introduced the subject of the evening, Factory Lighting, speaking of the general principles involved as related to the eye and illumination. Clarence E. Clewell of the electrical engineering department of the Sheffield Scientific School, gave a paper on applications of Lighting to Factories, with many illustrations of good and bad lighting, and a clear presentation of modern methods of securing good lighting and its economic value. T. J. Lytle of the Welsbach Company of Philadelphia described the latest improvements in the construction of gas lamps.

A very effective display of forms of gas units suitable for factories and auditorium was arranged through the courtesy of the New Haven Gas Light Company in the laboratory, and an exhibition of the lights was made at the close of Mr. Lytle's presentation.

More than 100 were in attendance at the meeting.

STUDENT BRANCHES

CASE SCHOOL OF APPLIED SCIENCE

The recently organized branch at the Case School of Applied Science, Cleveland, Ohio, has held several meetings, at one of which A. J. Himes, president of the Cleveland Engineering Society, spoke on The Advantages to the Engineer of Membership in an Engineering Society, and at another, E. P. Roberts, Mem. Am. Soc. M. E., gave an illustrated lecture on Some Phases of Power Plant Engineering. Plans are being made for the first annual meeting.

COLUMBIA UNIVERSITY

On March 27, R. V. Wright, Mem. Am. Soc. M. E., addressed the Columbia University Student Branch on Steel Cars and Their Construction.

CORNELL UNIVERSITY

The Sibley College Student Branch held a joint meeting with the American Institute of Electrical Engineers Student Branch on March 26, at which there was a debate on the question, Resolved, that marine power can be more efficiently utilized by the interposition of electric units be

tween the prime mover and the propellers. A. C. Voorhees (1913) and J. B. Norris (1913), on the negative side, won the debate.

LEHIGH UNIVERSITY

At a meeting of the Mechanical Engineering Society at Lehigh University on April 19, Mr. Larkin of the mechanical engineering department spoke of his experiences in beginning work after his graduation from college, and H. A. Freeman, manager of the Davis Regulator Company, gave a talk on Valves and Valve Regulation.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At the March 17 meeting of the Mechanical Engineering Society, Prof. I. N. Hollis, Vice-President, Am. Soc. M. E., delivered a lecture on The History of Steam Boiler Construction, in which he outlined the development of the steam boiler from the earliest times. The talk was illustrated with lantern slides.

On March 20, the members of the branch and the Electrical Society attended a smoker at the Technology Union, at which an illustrated lecture was given by Prof. H. W. Smith of the electrical department, on his travels among the tribes of the island of Sawarak.

E. H. Peabody, Mem. Am. Soc. M. E., addressed the meeting of March 28, the subject being Oil Burning. The lecture was illustrated with lantern slides.

On April 8, R. E. Curtis, Mem. Am. Soc. M. E., gave an address on Mechanical Drawings and the Drawing Room, in which he discussed the best methods employed in drafting, and the proper way a large drafting room should be conducted.

I. E. Moultrop, Vice-President, Am. Soc. M. E., gave a lecture on Power Plant Difficulties, at the meeting of April 14, in which he discussed boiler capacity, boiler setting, economizers, condensers, stokers and steam piping. A discussion by the student members followed.

PENNSYLVANIA STATE COLLEGE

On April 4, D. R. Mason, metallurgical engineer with the National Tube Co., addressed the Pennsylvania State College Student Branch on the Manufacture of Steel Tubing.

H. A. Hey, Assistant to the Secretary, Am. Soc. M. E., in an address at the meeting of April 8, set forth the advantages of student membership in the Society.

At the meeting of April 11, C. D. Young, Mem. Am. Soc. M. E., lectured upon the present practice in railroad work in the use of superheated steam, electrical engineering in steam road work, and apprenticeship courses for engineering graduates.

POLYTECHNIC INSTITUTE OF BROOKLYN

A meeting of the Polytechnic Institute Student Branch was held on April 5 when Prof. R. H. Fernald, Mem. Am. Soc. M. E., delivered a lecture on Producer Gas from Low-Grade Fuels.

PURDUE UNIVERSITY

At a regular meeting of the Purdue University Student Branch on April 8, Prof. G. W. Munro, Mem. Am. Soc. M. E., presented a Historical Resumé of Gas Turbines, in which he discussed the types and probable development. The talk was illustrated with lantern slides.

STATE UNIVERSITY OF KENTUCKY

At the last regular meeting of the University of Kentucky Student Branch, S. Rosenzweig of the Erie City Iron Works, delivered a lecture on Superheated Steam and Poppet Valve Engines. Lantern slides, showing the detailed construction of engine and valve gears, added interest to the lecture.

STATE UNIVERSITY OF IOWA

At the meeting of the Council on April 11, the establishment of a new student branch at the State University of Iowa was authorized.

STEVENS INSTITUTE OF TECHNOLOGY

On March 7 Jerome Strauss (1913) gave a talk before the Stevens Engineering Society on the Corrosion and Preservation of Iron and Steel. The speaker recalled how the hand-worked iron of former times withstood the attack of corrosive agencies better than the cheaper, quicker-made iron of today, and the theories of corrosion and the methods of protecting iron were discussed.

Dr. Chas. E. Lucke, Mem. Am. Soc. M. E., presented a paper on Heavy Oil Engines at the meeting of March 18. This was discussed by H. Torrance and R. H. Williams.

At the March 27 meeting, Dr. F. J. Pond, profesor of chemistry at Stevens Institute of Technology, delivered a lecture on Synthesis of Rubber. He began his lecture by a brief description of india-rubber or caoutchouc, which is obtained from the sap of certain tropical trees. The sap is coagulated by heat or by means of acid and the main constituent is the caoutchouc hydrocarbons. The principle upon which the synthesis of rubber depends is to produce these caoutchouc hydrocarbons without the aid of the vegetable sap.

The Electrification of the Steam Railroads in the Neighborhood of Boston from a General Economic and Engineering Point of View, by Dr. George F. Swain, Mem. Am. Soc. M. E., was given at the meeting of April 1. He emphasized the point that it was not a question of how to build but whether to build at all, and his considerations, therefore, were not electrical but financial and economic. This was discussed by J. H. Vander Veer (1911).

On April 8, F. E. Ford (1914), presented an illustrated lecture on Hydroelectric Power Development. The main essentials in considering hydroelectric propositions are accessibility of location, market for the product, cost of maintenance and fixed charges. J. H. Vander Veer, R. H. Williams, C. S. Trewin and M. R. Van Benschoten participated in the discussion.

UNIVERSITY OF ILLINOIS

L. D. Breedlove gave a talk on The Prevention of Accidents in Industrial Plants at the meeting of March 7 of the University of Illinois Student Branch, which was followed by a general discussion.

UNIVERSITY OF KANSAS

The fourth annual open meeting of the University of Kansas Student Branch was held March 27. The first session was opened by an address by Prof. P. F. Walker, Mem. Am. Soc. M. E., and the following papers were presented: Failures of Machine Parts, W. H. Tangeman (1912); Temperature Regulation and the Heating Engineer, F. A. DeBoos of the Johnson Service Company, Kansas City, Mo., and Fuel Testing and the Purchase of Coal by Specifications, Dr. Roy Cross. The paper by Mr. DeBoos was illustrated with lantern slides and models.

At the second session, Prof. F. H. Sibley, Mem. Am. Soc. M. E., read a paper on Block Signals. E. E. Howard, of Waddell & Harrington, Kansas City, Mo., gave a talk on The Design and Operation of Lift Bridges which was illustrated with slides of bridges in operation. An illustrated lecture on Superheated Steam and the Lentz Engine was also presented by S. Rosenzweig of the Erie City Iron Works.

In the evening, a banquet was given to the visiting speakers.

UNIVERSITY OF MISSOURI

At a special open meeting of the University of Missouri Student Branch on March 18, Prof. Wm. Kent, Mem. Am. Soc. M. E., delivered a lecture on Engineering and Common Sense.

UNIVERSITY OF WISCONSIN

An interesting exhibit of internal combustion engines was held at the University of Wisconsin, Madison, Wis., on February 27 and 28, by the Student Branch of the Society in coöperation with some of the agricultural students and with the assistance of various manufacturers, W. C. Rowse of the faculty acting as director of the affair. The exhibit was given in the Stock Pavilion of the Agricultural Department, and consisted of tractors, automobiles, motor cycles, general farm engines and utility engines and motor boats. It was open between 10 a.m. and 10 p.m., the machinery being run at certain hours during the day and evening so that the operating factors could be seen. The applications of this type of engine that could not be shown by exhibits were illustrated by lantern slides and lectures. Music was provided by the university regiment on both evenings, and the show proved to be of such a popular nature that the pavilion was crowded to its fullest extent both during the afternoon and evening. Although over a thousand free passes were given out by the dealers participating in the exhibit, and despite the low cost of admission, ten cents, the attendance was so large that over one hundred dollars was realized after the meeting of all expenses.

YALE UNIVERSITY

An engineering exhibit, showing the apparatus in use at the Mason Laboratory of Mechanical Engineering, together with that of certain manufacturing firms, was held at Sheffield Scientific School, Yale University, on February 21 and 22, under the auspices of the student branches of the national societies. It was planned by the students for the benefit of the university and their friends, so that all might examine the equipment of the laboratory. The apparatus included testing machines, special testing apparatus, sewage disposal plant, sanitary chemical analysis of water, testing of reinforced concrete, steam engines, ore testing machinery, electrical machinery, and many others.

NECROLOGY

EDWARD L. BRONSON

Edward L. Bronson, who died at his home in Waterbury, Conn., on February 18, 1913, was born at Wolcott, Conn., on May 18, 1860. His education was received in the public schools and in the Lewis Academy, Southington, Conn. Upon leaving school he apprenticed himself to the Hendey Machine Company in Torrington.

In 1886 he entered the employ of the Waterbury Farrel Foundry & Machine Company at Waterbury, as machinist, and later in the same year resigned to take up similar work with the E. J. Manville Machine Company. Three years later he became connected with J. E. Draper & Company, North Attleboro, as a tool maker, but soon returned to Waterbury to become foreman of the machine department of Blake & Johnson, machinists and manufacturers of piano hardware, etc. In 1896 he again entered the employ of the Manville Company, now as foreman of special machinery and tool making, and remained with them until he became master mechanic of the Shoe Hardware Company, with which he was connected until shortly before his death. His was no small part in the development of the factory to its present importance.

Mr. Bronson was especially interested in automatic machinery and with A. C. Campbell invented an improvement in dress hook machines, which resulted in increasing the speed of production from 70 to 220 hooks per minute.

GEORGE W. CLANCY

George W. Clancy, president of the Globe Chemical Company of Boston, died at his home in Albany on March 10, 1913. Mr. Clancy was born in Albany on February 22, 1881, and after completing his education in the public schools entered the shops of Skinner & Arnold of that city, where he learned the machinist's trade. He then entered the employ of the New York Central at West Albany and was transferred to the Boston & Albany

Railroad in 1904, becoming inspector of shops. In 1908 he left to accept a similar position with the New York, New Haven & Hartford Railroad. While with this company he received an offer to become manager of the railway sales department of the Adams & Elting Company, Chicago, and was with this concern at the time of his death.

COLIN C. SIMPSON

Colin C. Simpson, assistant secretary and general superintendent of mains of the Consolidated Gas Company, died in New York, April 8, 1913. Mr. Simpson was born at Maidstone, England, on December 16, 1856, and received his education in private schools, the Technical High School of Gratz, Austria, and the Naval Academy at Trieste, Austria. He began his career with an English contracting firm laying water mains in Vienna, and during his connection with them invented a machine for tapping mains while under pressure without allowing water to escape.

In 1880 he came to the United States and entered the engineering department of the Knickerbocker Gas Company. Two years later he was placed in charge of mains of the Municipal and Knickerbocker Gas Companies, and at the time of their consolidation in 1884 into the Consolidated Gas Company, was made district superintendent of mains. From this he rose to the general superintendency and also to the position of assistant secretary, in both of which he continued up to the time of his death.

Mr. Simpson had an unusual acquaintance with sub-surface conditions in New York City, having had charge of the design and construction of all gas mains laid in Manhattan since 1884. He designed and successfully laid during 1910 and 1911 two 36-inch and one 48-inch main across the Harlem River, one of the most difficult problems in connection with main work. He also laid the East River Gas Company's 60-inch steel main from the Astoria Works to Ravenswood, the largest gas main in the world. He was the first man to use lead wool for pipe jointing in this country, having imported this material from Germany before it was manufactured here. He was a leading exponent of absolute safety with respect to gas mains, and designed and secured the adoption of the system of bypassing of all gas mains, now in general use during the construction of the subways.

Mr. Simpson had a very wide acquaintance among his profes-

sion and was frequently called upon as an expert in damage suits against gas companies. He appeared before the United States Supreme Court in the New York Eighty-Cent Gas Case and established the value claimed for the mains under his charge. He was a member of the American Gas Institute, the Engineers Club, the Society of Gas Engineering, the Society of Illuminating Engineers, and the National Democratic Club.

CHARLES E. TOMLINSON

Charles E. Tomlinson was born February 14, 1868, in Auburn, N. Y., and was educated in the public schools of that city and of Syracuse. He entered the field of mechanical engineering by serving as an apprentice with a number of firms, including the L. C. Smith Gun Company, LaFevere Arms Company, Weston & Smith and I. Weston & Company, drafting machinists, designers and builders, Duell, Laass & Duell, Emil Laass & Company, Hey, Wilkinson & Parsons and Hey & Parsons, patent solicitors and attorneys, all of Syracuse, N. Y. In 1900 he entered the employ of the Remington Typewriter Company as designer and draftsman, and in 1903 transferred to their Smith Premier plant, with which he was connected at the time of his death, on March 10, 1913. Mr. Tomlinson designed and constructed the various parts of the typewriter for the Remington Company, and during the latter years of his life was occupied mainly in expert work on patents and related questions.

AARON VANDERBILT

Aaron Vanderbilt of Remsenburg, New York, died on March 25, 1913. He was born January 29, 1844, and was educated in the public schools of Staten Island and Brooklyn. Throughout his professional career he was connected with marine work and had no technical training other than that gained by experience.

He was at one time manager of the Ward Steamship Company, and at the time of the formation of the Society, of which he was one of the charter members, superintendent of the New York and Cuba Mail Steamship Company, and from 1900-1908, when ill-health forced him to retire from active work, vice-president of the Wheeler Condenser & Engineering Company. He was especially interested in marine engines and gave much time and study to their development.

During the Civil War while on Admiral Porter's staff he drew plans of the enemy's fortifications at Fort Fisher and elsewhere.

Mr. Vanderbilt was elected to life membership in the Society in 1908. He was a member of the United States Naval Institute, the Naval Order of the United States, the Society of Marine Architects and Naval Engineers, the Navy League, the Grand Army of the Republic, and the military order of the Loyal Legion. He was largely instrumental in the formation of the Naval Reserve and the Navy League, and was at one time chairman of the committee on ocean transportation of the New York Board of Trade.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month The list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

358 Young graduate mechanical engineer in estimating department of Pennsylvania concern making gas engines and producers, steam engines, boilers, tanks, etc. The work would cover estimating material and labor costs on boiler shop construction; preference for someone who has had actual experience in the boiler shop estimating line, and who can be depended on to stay after becoming proficient in the work. Salary depends on man's capabilities and experience.

359 Foreman in small plate and structural shop. Must be good layer-out and all-around man able to keep accurate cost records and get results. State age, experience, references and salary expected. Location Springfield, Mass.

363 Technical graduate from 25 to 30 years old, as assistant to head of engineering and maintenance departments of firm manufacturing paper and finished paper products. Headquarters in Massachusetts. Should have had general experience in upkeep of an industrial plant rather than some specialty. Applications must include full details as to previous history and salary wanted.

400 Recent graduates in mechanical engineering, who will be ambitious and willing to work hard. Location Niagara Falls, N. Y.

401 Technical expert in purchasing department of a large works near New York, making high-grade light metal products, to assist in selecting, buying and inspecting the many varied materials used. Should be good metallurgist, fair chemist and familiar with fuels. Apply through the Society, giving age, education, experience, reference and approximate salary required.

402 Mechanical engineer with experience in production engineering, or in the Taylor system of scientific management or one having a liking for this kind of work; Cleveland concern.

403 Man with ability to decrease costs and increase production, required to operate rapidly growing department of St. Louis manufacturing plant. Ability to grasp and develop special features is necessary. Practical shop and premium system experience desired. Salary $125 upward.

404 Sales engineer for high-grade steam engines. Must be a man capable to instruct and advise other salesmen. Location New York State.

405 Position open for engineer familiar with steam pumps, centrifugal pumps and air compressors, and with some experience along the line of salesmanship. Michigan concern.

406 Engineer on power plant design, operation, estimating, testing and mechanical construction. Location Massachusetts. Apply through Society.

407 Young technical graduate, familiar with power plant work, experience in stoker construction preferred. Salary $1500; good opportunity for advancement. Location Massachusetts.

409 General superintendent, with wide shop experience and thoroughly conversant with all modern tools and methods, good organizer with ability to handle men to the best advantage. Location Detroit. Apply through the Society.

410 Man to take charge of mechanical end of plant to oversee boiler and steam plants as well as repair work and new construction. Will pay liberal salary for right man with ability to handle men and do the work. Location Chicago.

411 Man with thorough knowledge of metallurgy to undertake the introduction of an important new process of case-hardening. Will need broad engineering training as well as business experience.

412 Instructor in experimental engineering for the school year 1913-1914. Location Oregon.

414 Detailers for steel work of office and mill buildings. Salary $125 a month. Location San Francisco.

MEN AVAILABLE

82 Member, mechanical engineer, desires to hear from manufacturers of power plant equipment and specialties who desire a representative in Rochester, N. Y., and vicinity.

83 Member, 15 years' practical experience, mainly in hydraulics and steam turbine design, now teaching machine design and related subjects for the second year, desires teaching position in machine design or mechanical engineering.

84 Member, technical graduate, 18 years' experience in shop, designing and layouts, testing materials and machines, now teaching, wishes to locate South or East, preferably with consulting engineer or technical school.

85 American, technical graduate, 10 years' experience in design of cranes and hoisting machinery, seeks responsible position with progressive firm as designing engineer, chief draftsman or similar work.

86 Superintendent, Member, age 40, experienced in shop systems, and modern methods of manufacturing Diesel and semi-Diesel oil engines; good executive, with last employer 15 years, desires position as superintendent or works manager. At present employed.

87 Member, at present employed, 18 years' varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of large industrial plants and equipment, systematizing of shops and processes along the lines of scientific management, testing and general plant engineering; accustomed to handling men, drawing up contracts, purchasing equipment and material, appraising properties; desires to become

identified with manufacturing or industrial plant of prominence in administrative or executive position of responsibility in which his experience may be of value.

88 Graduate mechanical engineer, 8 years' experience, partly drafting and designing, but mainly in research and experimental work along lines connected with steam engineering. At present employed, available about August 15. Best of references.

89 Technical graduate, age 37, practical mechanic with 15 years' experience in executive and designing capacity in varied lines, desires position as superintendent or mechanical engineer. Open to engagement May 1.

90 Technical graduate, age 37, practical mechanic with 10 years' experience in executive capacity, mill engineering, power generation, transmission, etc., desires position as factory engineer or works manager with progressive concern in New England.

91 Member, now employed, with 17 years' experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, graduate Massachusetts Institute of Technology in mechanical engineering, post-graduate course in electrical engineering, desires permanent administrative or executive position in New York City.

92 Member, 32, desires position in New York or vicinity, with a firm engaged in design and construction of plants, or with industrial engineers. General experience in mill building and in power plants.

93 Manager and engineer equally capable in charge of sales department, advertising, correspondence or shop. Technical degrees of mechanical and electrical engineer (University of Pennsylvania), followed by 9 years of practical shop, drawing-room, office, and traveling sales experience. Four years with present firm and manager of a sales department.

94 Associate, age 35, with 17 years' broad experience in drawing-rooms on civil, structural and mechanical work, desires a position of some responsibility (preferably not drawing), in or near Philadelphia. Experience on furnaces, mill work, power plants, chemical apparatus, gas plants, coke ovens, etc. Salary about $1500 to begin.

95 Member, age 33, Cornell, M.M.E., 10 years' practical and technical experience along internal-combustion engine lines, in designing, testing, erecting service and sales work. Specialty, factory production and inspection systems to produce interchangeable parts. At present employed. Desires position of responsibility with stationary gas engine or traction engine concern in the Middle West. Salary $3600. Good references.

96 Technical graduate, 26 years' experience in shop, teaching applied mathematics, experimental mechanics and engineering physics, 15 years in engineering and contracting, covering refrigeration, water supply, power and lighting plants, including machinery and buildings, testing process development and consulting work over a wide range of subjects. At present acting professor of engineering practice in a prominent engineering school. Has no family ties and would like position in Orient or south of equator.

97 Technical graduate, Junior Member, 10 years' practical experience. At present engaged as superintendent of manufacturing concern, but desires to make change to larger field. Experience covers design and manufacture of interchangeable parts and machinery, tools, jigs, and fixtures for increasing production, etc. Good references.

98 Mechanical engineer with long practical shop and drawing-room experience, resourceful in design, especially well experienced as chief draftsman in carrying out designs at reasonable cost in the drawing-room of engines, pumps, heaters and condensers of all descriptions, the specialty, is open for engagement. Splendid record and references.

99 Mechanical engineer having thorough practical knowledge combined with technical education, conversant with steam and water, desires position as master mechanic of large industrial plant.

100 English-speaking graduate German technical school, with foreign experience in landscape architecture and city planning, including surveying, analysis of soils, building construction, canal and railroad construction, hydraulics, meteorology, etc., desires to locate in America.

101 Teacher of mechanical engineering subjects, at present in one of the largest schools in the East, desires to change to Middle or Far West. Eight years' experience, before taking up school work, as designer and chief engineer on steam and gas engineering work, pump compressors and general power plant work. Member. Excellent references. Minimum salary $1800.

102 Designer of broad experience, familiar with presses and dies for sheet metal work, and with tools, jigs and fixtures for efficient production, will soon be available for work of this class in the Middle West.

103 Member, professor of experimental engineering in a large Eastern university, desires summer work. Has had shop experience, engine room service at sea and a general experience in testing work and miscellaneous engineering problems.

104 Member, experienced in engineering and physical research, formerly in charge of design and construction of internal-combustion engines, later in charge of testing laboratory, and thoroughly conversant with latest theory of thermodynamics as teacher, desires an opening in responsible charge or as professor.

105 Power plant specialist and consulting engineer desires connection with editorial staff of leading technical periodical, and working agreement with bankers, investors or others contemplating development along mechanical or industrial lines.

106 Junior member experienced in cost and efficiency work and factory management, at present with financial house; desires position as factory manager of medium-sized industrial plant or assistant to manager of larger works.

107 Student member, will graduate from Stevens Institute in 1913, desires a position in which the prospects are good. Interested in electrical or hydraulic lines.

108 Cornell graduate, age 27, would like to engage in work along engineering sales. Experience in power specialties, boiler and furnace practice, mechanical and works engineer.

109 Experienced executive now located in Cincinnati desires consideration as superintendent or production manager. Experienced on machine tools, autos, and electric machinery, up-to-date on shop management, methods and system, installed the premium system and good success in organizing and handling men, practical experience, technically trained, age 37, married.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

American Railway Bridge and Building Association. Proc. 19th annual convention. *Chicago, 1909.* Gift of association.

The American Society of Mechanical Engineers. Year Book 1913. *New York, 1913.*

Attitude of Labor Towards Scientific Management, Hollis Godfrey. Gift of author.

Automobiltechnisches Handbuch, Ernst Valentin. ed. 7. *Berlin, 1913.*

British Fire Prevention Committee. Fire Tests with Doors. Red Book no. 173. *London, 1912.*

——Fire Tests with Roof Coverings of Asbestos Cement Corrugated Sheets. Red Book no. 174. *London, 1913.*

Carnegie Foundation for the Advancement of Teaching. 5th and 7th Annual Reports of the President and of the Treasurer. *New York, 1910, 1912.* Gift of the Society.

La Chaufferie Moderne. Alimentation des Chaudieres et Tuyauteries de Vapeur, J. Guillaume and André Turin. *Paris, 1912.*

Civil Engineer and Architect's Journal. vols. 1–26. *London, 1837–1863.*

Constructions Métalliques, J. Bonhomme and E. Silvestre. *Paris, 1913.*

Die Dampfmaschinen, A. Pohlhausen. vol. 2. *Mittweida, 1912.*

The Design of Alternating-Current Machinery, J. R. Barr and R. D. Archibald. *New York, Macmillan Co., 1913.*

The book was written by Mr. Barr, a lecturer in Heriot-Watt College, Edinburgh, and revised by Mr. Archibald. It is for students in advanced electrical engineering, and gives adequate mathematical treatment.

Diesel-Motoren, G. Supino and H. Zeman. *München, Berlin, 1913.*

Edinburgh University. Calendar 1912–1913. *Edinburgh, 1912.* Gift of university.

L'Effet Gyrostatique et ses Applications, E. W. Bogaert. *Bruxelles-Paris, 1912.*

Electric Power from the Mississippi River. bull. no. 9, March 1913. *Keokuk, 1913.* Gift of Mississippi River Power Co.

Etude Théorique et Pratique sur le Transport et la Manutention Mecaniques des Matériaux et Marchandises dans les Usines, les Magasins, les Chantiers, les Mines, etc., Georg von Hanffstengel. vols. 1–2. *Paris, 1910–1911.*

Experimental Study of Heat Transmission and Entrainment in a Vacuum

Evaporator. Louisiana Agricultural Experiment Station, bull. no. 138. *Baton Rouge, 1913.* Gift of Louisiana State University.

Gas Power, C. F. Hirshfeld and T. C. Ulbricht. *New York, J. Wiley & Sons, 1913.*

This elementary manual is designed for students in manual training schools and others who wish to learn enough of the gas engine to serve as an introduction to more advanced works. There is a minimum of mathematical treatment. The authors are members of the faculty of Cornell University.

Die Gebläse, Albrecht von Ihering. ed. 3. *Berlin, 1913.*

Goethals, George W., Banquet Tendered to, by New York Lehigh University Club, January 27, 1913. N. Y. Lehigh University Club.

Great Britain Patent Office Library. Guide to the Search Department. *London, 1913.* Gift.

Harvard University. Reports of the President and the Treasurer, 1911–1912. *Cambridge, 1913.* Gift of university.

Hussey, Obed. Edited by Follett L. Greeno. *Rochester, N. Y., 1912.* Gift of editor.

The book is controversial rather than biographical, and is designed to support Hussey's claims as the original inventor of the reaper.

Hydraulisches Rechnung, R. Weyrauch. ed. 2. *Stuttgart, 1912.*

Über Kapok, E. L. Lincke. *Dresden, 1912.*

Der VI Kongress des Internationalen Verbandes für Material-prüfungen der Technik, New York, 1912, Alfred Deinlein. *Wien, 1913.* Gift of H. F. J. Porter.

Koninklijk Instituut van Ingenieurs. Year Book 1913. *'s-Gravenhage, 1913.* Gift of institute.

Legal Aid Society. 37th Annual Report of the President, 1912. *New York, 1913.* Gift of society.

Lehrbuch der Thermodynamik, J. D. v. d. Waals. *Leipzig, 1908.*

Les Lois Expérimentales des Hélices Aériennes, Alexandre Sée.

Lowell Textile School. Annual Report of the Trustees, 1912. *Boston, 1913.* Gift of school.

Machinists' and Draftsmen's Handbook, Peder Lobben. ed. 2. *New York, Van Nostrand Co., 1910.* Gift of author.

A compilation of facts and tables for the working mechanic. It is full of practical information; an encyclopedia of machine-shop practice.

Neuere Kühlmaschinen ihre Konstruktion Wirkungsweise und industrielle Verwendung, Hans Lorenz and C. Heinel. ed. 5. Oldenburgs Technische Handbibliothek, vol. 1. *München, 1913.*

New York Central and Hudson River Railroad Company. 44th Annual Report to the Stockholders, 1912. *New York, 1912.* Gift of company.

Ohio University. Bulletin of Summer School. *Athens, 1913.* Gift of university.

Pittsburgh Bureau of Water. Annual Report February 1, 1911 to January 31, 1912. Gift of superintendent Bureau of Water.

Poor's Manual of Railroads, 1913. *New York, 1913.*

Précis d'Hydraulique, Georges Daries. *Paris, 1912.*

Public Health Service not a Medical Monopoly, Morris Knowles. Reprinted from American Journal of Public Health. Gift of author.

Der Schraubenpropeller (Schiffsschraube) Konstruktion und Berechnung desselben, C. Dreihardt. *Berlin, 1906.*

Society for the Promotion of Engineering Education. Proc. vol. 20, pt. 1. *Ithaca, 1913.* Gift of society.

Steam Boiler Explosions, W. H. Boehm. *1912.* Gift of Fidelity and Casualty Company of New York.

Symposium on Scientific Management and Efficiency in College Administration. *Ithaca, 1913.* Gift of Society for the Promotion of Engineering Education.

A Thousand Uses for Gas. An alphabetically arranged list of over one thousand uses for gas as applied in the arts and trades. *1913.* Gift of National Commercial Gas Association.

Throop Polytechnic Institute. President's Fourth Annual Report. Bulletin April 1913. *Pasadena, 1913.* Gift of institute.

Transporter Bridges, H. G. Tyrrell. *Toronto, 1912.* Gift of author.

University of Edinburgh. Copy Register of Members of the General Council, 1911. *Edinburgh, 1911.* Gift of the Society.

University of Toronto. Calendar, Faculty of Applied Science and Engineering 1913–1914. *Toronto, 1913.* Gift of university.

Über Wasserkraft und Wasser Versorgungslagen, F. Schlotthauer. ed. 2. Oldenbourgs Technische Handbibliothek, vol. 7. *München-Berlin, 1913.*

Die Werkzeugmaschinen und ihre Konstruktionselemente, Fr. W. Hülle. *Berlin, 1913.*

Worcester Polytechnic Institute. 43d Annual Catalogue, 1912–1913 *Worcester, 1913.* Gift of institute.

UNITED ENGINEERING SOCIETY

Congres Géologique International XII Session. Second circular, February 1913. *Canada, 1913.* Gift of Victoria Memorial Museum.

Cumulative Book Index, books published 1912. *Minneapolis, 1913.*

Engineering. vol. 36, 1883. *London, 1883.* Gift of John Wiley.

Fünfunddreissigster Jahresbericht über die Tätigkeit der Deutschen Seewarte, 1912. *Hamburg, 1913.* Gift.

Moody's Manual of Railroads and Corporation Securities, 1913. *New York, 1913.*

Oil, Paint and Drug Reporter. Buyers Directory, 1913. *New York, 1913.* Gift of Oil, Paint and Drug Reporter.

"Sweet's" Catalogue of Building Construction, 1913. *New York, 1913.* Gift of Wm. B. Bamford.

EXCHANGES

American Gas Institute. Proceedings. vol. 7, 1912. *1913.*

American Society of Refrigerating Engineers. Transactions. vol. 6. *New York, 1910.*

Deutsches Museum. Bibliothek-Katalog. *Leipzig, 1907.*

———Bericht über die unter dem Vorsitze, Sr. Königl. Hoheit des Prinzen Ludwig von Bayern, June 28, 1903. *München, 1903.*

———Description of.

———Führer durch die Sammlungen. *Leipzig.*

———Mitglieder-Verzeichnis, 1909–1910.

———Verwaltungs Bericht über das Geschäftsjahr 5, 7, 8, 1908–1911. *München, 1908–1911.*

———A Walk Through the Collections.

Société des Ingenieurs Civils de France. Annuaire de 1913. *Paris, 1913.*

U. S. Naval Observatory. Annual Report 1912. *Washington, 1912.*

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Johns-Manville Co., *Cleveland, O.* J-M. Power Expert, March 1913.

Penberthy Press, *Detroit, Mich.* Penberthy Engineer and Fireman, March 1913.

Under-Feed Stoker Co., *Chicago, Ill.* Publicity Magazine, March 1913.

Wood, W. H. Loco Fire Box and Tube Plate Co., *Media, Pa.* Explanatory reference to the diagram of Wm. H. Wood's patent locomotive firebox and tube plates.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913

Wm. F. Durand
Ira N. Hollis
Thos. B. Stearns

Terms expire 1914

James Hartness
I. E. Moultrop
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Stanley G. Flagg, Jr.
E. B. Katte

Terms expire 1914

Chas. J. Davidson
Henry Hess
Geo. A. Orrok

Terms expire 1915

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George Westinghouse
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Geo. A. Orrok
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Meetings

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L. P. Alford (2)
H. E. Longwell (3)
H. L. Gantt (4)
R. H. Fernald (5)

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C. I. Earll (3)
I. E. Moultrop (4)
F. R. Low (5)

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C. L. Clarke (1)
Alfred Noble (2)
E. G. Spilsbury (3)
The Secretary

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E. Van Winkle (1), *Chmn.*
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F. A. Scheffler (5)

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R. D. Mershon (5)

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G. M. Brill (5)

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F. W. Taylor

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E. D. Meier

A. A. A. S.

A. C. Humphreys
W. B. Jackson

John Fritz Medal

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F. R. Hutton (3)
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A. C. Humphreys (1)
F. J. Miller (2)
Jesse M. Smith (3)

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C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

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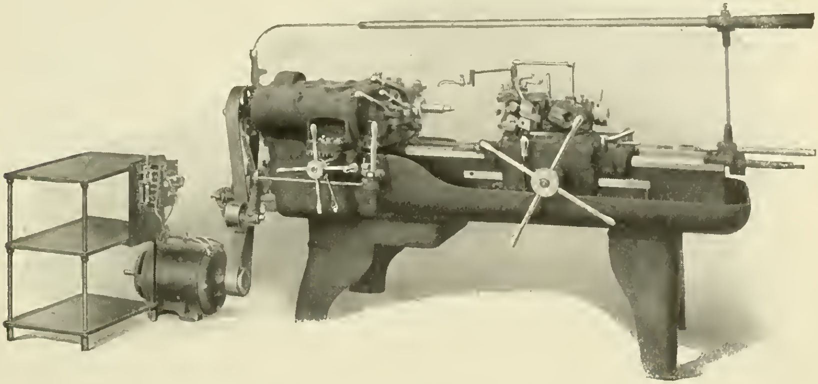

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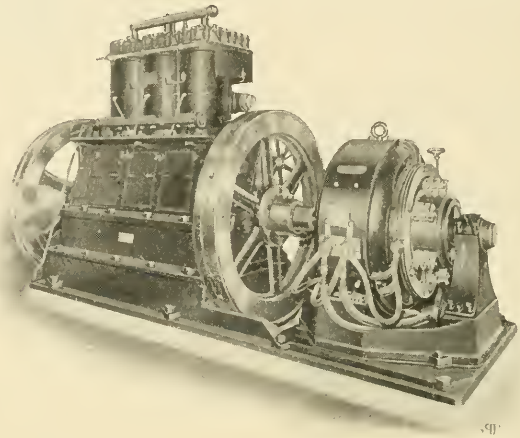

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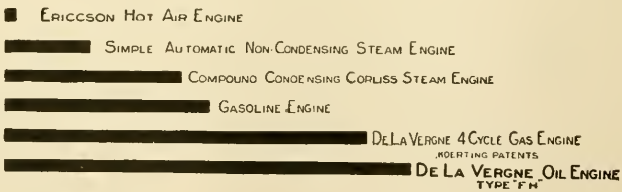

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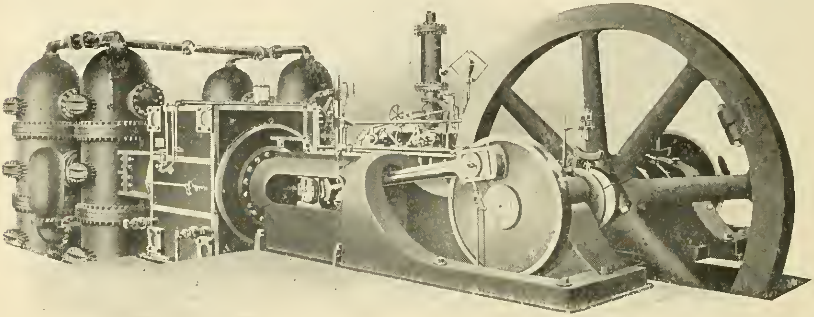

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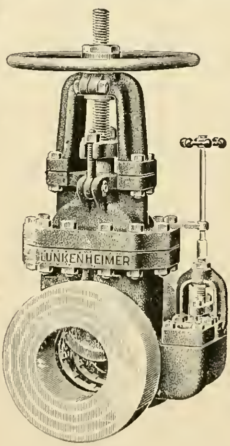

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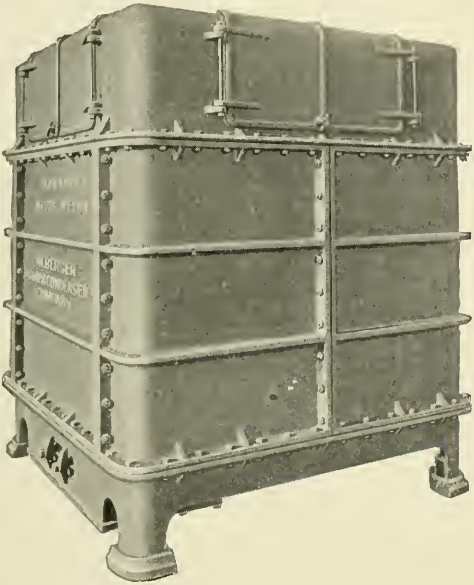

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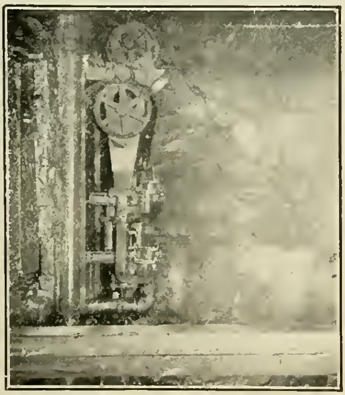

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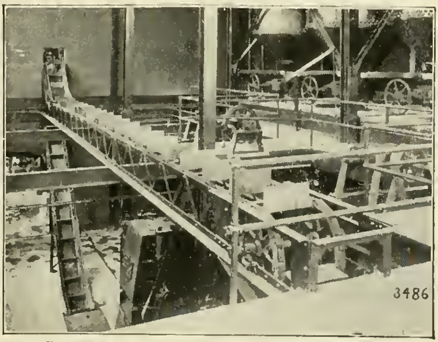

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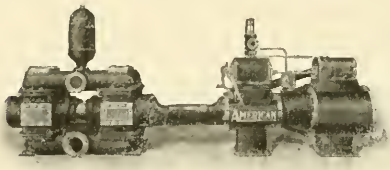

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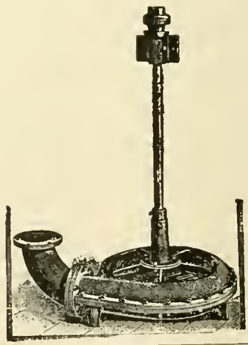

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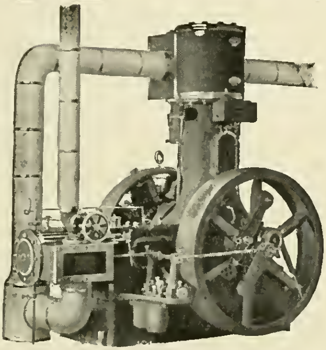

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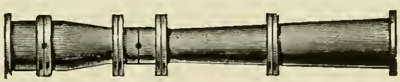

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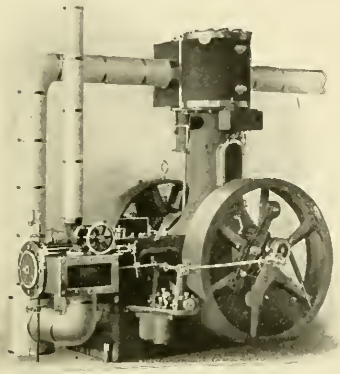

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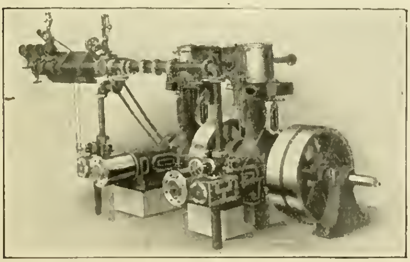

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			Length	Width	Steam	Exhaust					Length	Width	Steam	Exhaust	Direct Connected Engine	Engine and Dynamo
120	12 & 19 x 10	325	103	85	4	6	12,000	75	12 & 19 x 10	325	103	107½	4	6	12,200	17,000
160	13 & 20 x 11	300	111	93½	4	7	14,900	100	13 & 20 x 11	300	111	112	4	7	15,200	21 100
250	16 & 25 x 12	285	125	110	6	9	23,000	150	16 & 25 x 12	285	125	120½	6	9	21,400	32,200
325	18 & 28 x 14	260	138	126	6	10	30,000	200	18 & 28 x 14	260	138	132½	6	10	27,900	40,000
400	20 & 32 x 15	250	145	141	7	12	37,600	250	20 & 32 x 15	250	145	156½	7	12	31,700	45,000
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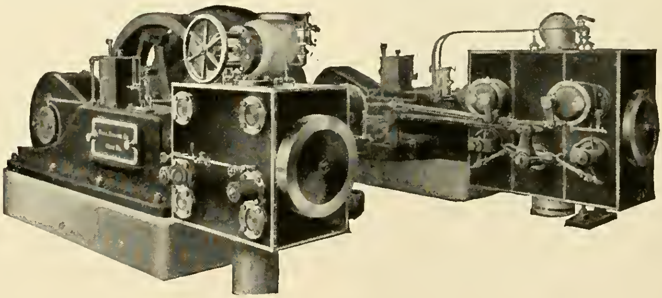

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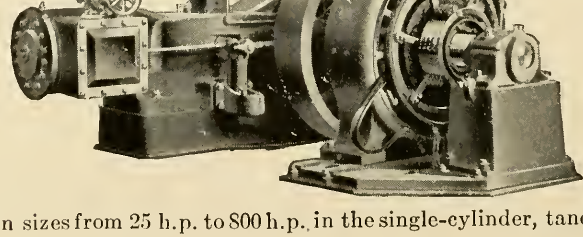

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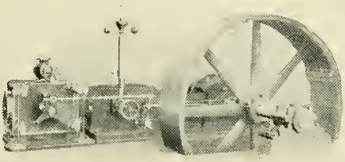

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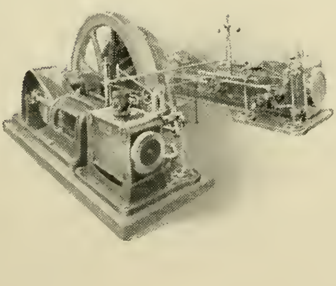

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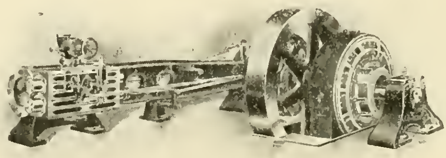

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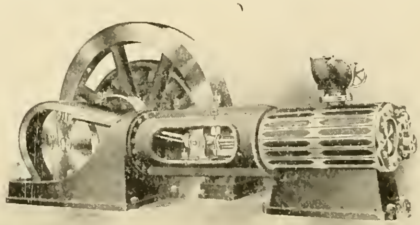

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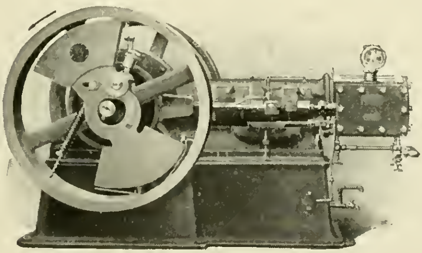
Sizes — 2 to 100 H. P.

TROY SELF-OILING ENGINES



Horizontal Automatic Type
for Belted Service

The economy of operation and maintenance of Troy Self-Oiling Engines is better than obtained in many common types of steam engines. The original design has proved excellent and progressiveness in important details has made the Troy Engine gratifyingly successful. The following brief mention of construction details are of interest.

Balanced Valves that are built steam tight and remain steam tight. Neither loss by leakage nor expense for repairs.

Long Connecting Rods, lessening the friction on the guides, thus saving power and securing longer life for the bearings.

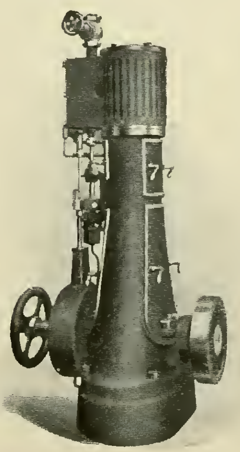
Patent Locking Device for the crank pin bolts, making accurate adjustment easy, and providing strength and security at this important point in the engine.

A Self-Oiling System (patented) that thoroughly lubricates, saves oil and operates automatically. The bearings run in oil, minimizing wear, and the cost of lubrication is less. The oil pump and the check valve are designed especially for this service and are particularly strong features, as they should be.

The Babbitt and the Brass used in bearings are made by Troy formulas which have been worked out to provide the most durable bearings.

Automatic Governor Engines have a regulation which varies less than 2 per cent.

Each order receives personal attention so as to adapt the engine in the nicest possible manner for the service it has to perform. This has particular importance when the engine has special details in construction for direct connected or similar work, and always insures the purchaser getting just the equipment needed.



Special Type of Vertical Throttling
for D. C. to Fan or Blower

THE NORDBERG MFG. COMPANY

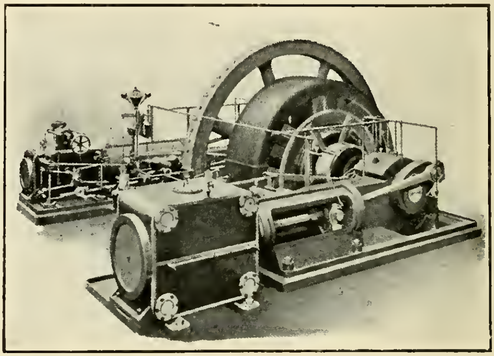
MILWAUKEE, WIS.

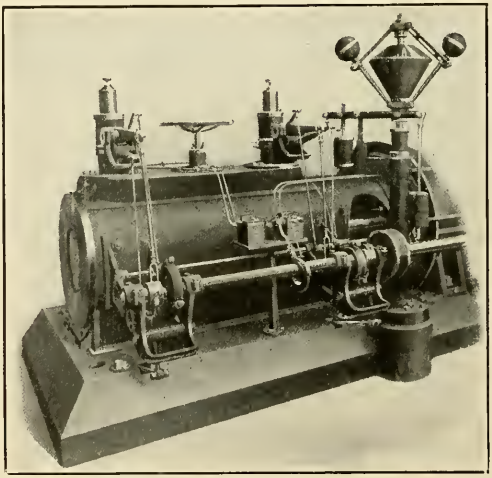
ENGINEERS, DESIGNERS AND BUILDERS OF

HIGH EFFICIENCY CORLISS ENGINES, UNIFLOW ENGINES, POPPET VALVE ENGINES, AIR COMPRESSORS, BLOWING ENGINES, HOISTING ENGINES, PUMPING ENGINES AND STEAM STAMPS.

CORLISS ENGINES: This Company builds a complete line of the highest grade Corliss Engines of standard design and also Nordberg full stroke Corliss Engines (cut-off up to 8/10 of stroke under full control of governor), high speed Corliss Engines and heavy duty Corliss Engines.

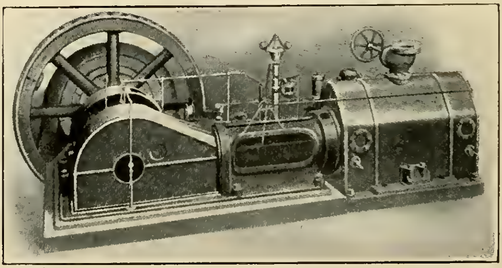
Nordberg Engines are built in horizontal, simple, duplex, tandem compound, cross compound and vertical types; for driving electrical machinery, for belt drive, rope drive and general power purposes, and for combination with compressors, blowing engines, pumping engines, etc.





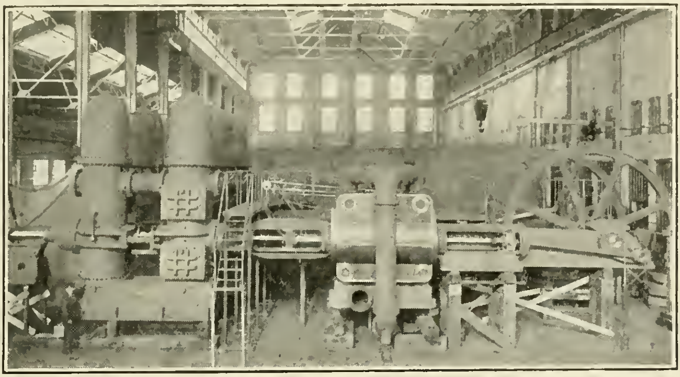
NORDBERG EQUILIBRIUM POPPET VALVE ENGINES: This Company has manufactured poppet valve engines for over 20 years. The fundamental advantage of the poppet valve engine is its ability to use steam at high pressures and high superheat, secondly a poppet valve remains steam tight for an indefinite period. This is demonstrated by a recent test on the famous Champion Copper Co. Compressor (which holds the world's record for steam economy). The high pressure cylinder which receives steam at 250 lbs. pressure is fitted with Nordberg Equilibrium Poppet Valve gear. A short time ago the full steam pressure was turned on the cylinder, and not the slightest trace of steam could be noticed in the exhaust, demonstrating fully the absolute tightness of the valves, even after eight years of service.

NORDBERG UNIFLOW ENGINES: The Uniflow Engine, invented over 25 years ago, has been developed in Germany, largely by Prof. Stumpf, and in this country, a Uniflow Engine to meet American conditions, has been designed by Mr. B. V. Nordberg, and over 150 tests under all steam conditions have been made. The primary advantage demonstrated by these tests is the enormous overload capacity of the Nordberg Uniflow Engine with flat steam consumption curve. By actual comparison with the performance of the best known types of American Turbines, the Nordberg Uniflow Engine not only has a lower steam consumption curve, but the percent increase in steam consumption with underloads is also far less than with the turbine.



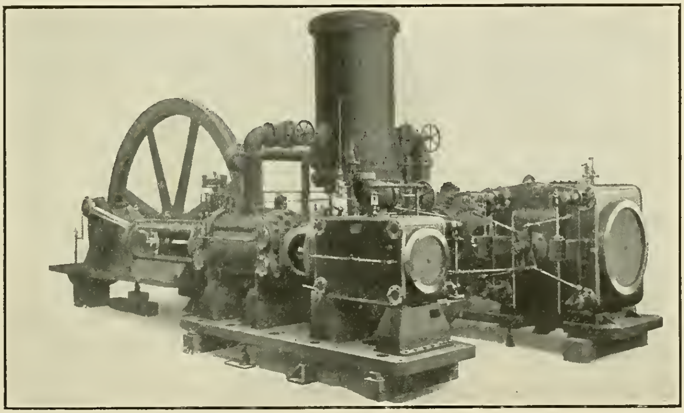
We are building complete Nordberg Uniflow Engines, and also equipping existing engines with Uniflow cylinders.

THE NORDBERG MFG. COMPANY

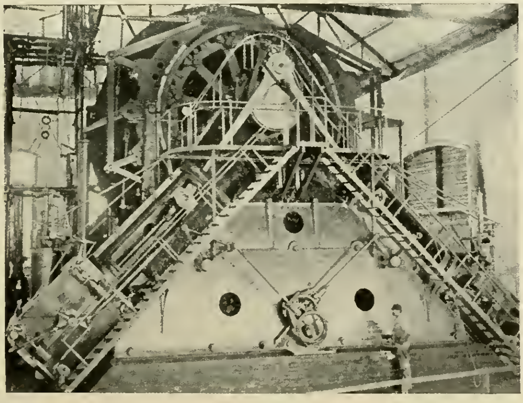


NORDBERG PUMPING ENGINES: The photograph shows a Nordberg Pumping Engine, built for the Utah Copper Company, capacity 10,000 gallons per minute against 265 ft. head.

The Nordberg Mfg. Company builds the highest duty compound, triple and quadruple expansion pumping engines with or without the Nordberg regenerative feed water heating system with which the highest steam economies in the world have been obtained.



NORDBERG COMPRESSORS: The above photograph shows a Nordberg horizontal cross compound two-stage full Corliss Air Compressor. Besides full Corliss Compressors, which are built in the largest sizes and have shown, for example at the Champion Copper Co. Mine, the highest recorded steam economy in the world, the Nordberg Mfg. Company also build a line of small compressors ("SC" Type) in capacities from 300 ft. up for belt drive. The compressors are compactly designed, fool-proof, enclosed and self-contained with automatic lubrication.



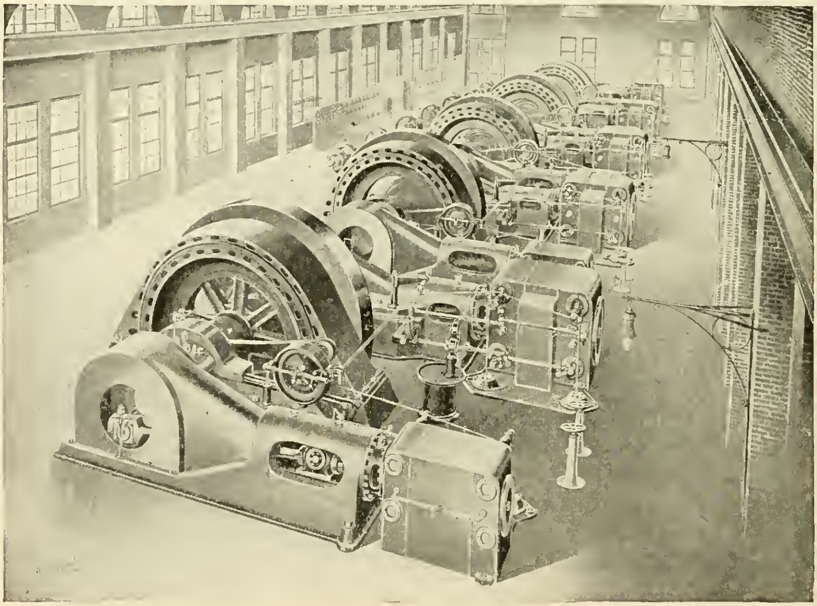
HOISTS: This photograph shows the largest hoist in the world, furnished to the Tamarack Mining Co., Mich. The Nordberg Mfg. Co. has made more hoists for great depths than all other builders in the U. S. combined.

Other products of this Company include Nordberg Steam Stamps, Symons Disc Crushers, Blowing Engines, Condensers, Vacuum Pumps and special machinery.

PROVIDENCE ENGINEERING WORKS

PROVIDENCE, R. I.

RICE & SARGENT CORLISS ENGINES, SPECIAL MACHINERY AND MACHINE PARTS TO ORDER, REPAIRS TO ALL TYPES OF ENGINE, COMPLETE RECORDS, DRAWINGS AND PATTERNS OF IMPROVED GREENE ENGINE.



The Rice & Sargent Corliss Engines are built in all usual types, for all purposes for which a high grade Corliss engine is required. They are built in all sizes, from 150 Horse Power to the largest desired. They are designed throughout for speeds considerably higher than are usual for other Corliss engines, making them especially suited to direct-connected electrical work.

Rice & Sargent Corliss Engines are built in one grade only—the same patterns, material and workmanship are used on every engine as on those installed in some of the country's finest steam plants.

Remarkable results have been obtained in a number of very accurate tests as regards steam consumption, regulation and mechanical efficiency.

Bulletins describing the details of construction and the result of tests will be sent to anyone.

Fully equipped separate departments—a competent engineering force—and a corps of trained and efficient workmen is maintained to manufacture special machinery or machine parts of any nature to order.

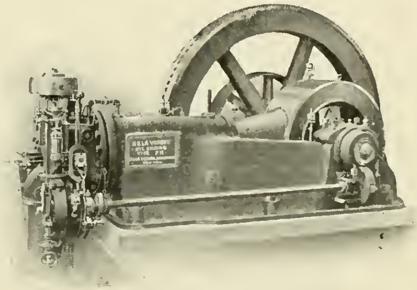
DE LA VERGNE MACHINE CO.

1123 EAST 138TH STREET - - NEW YORK CITY

DE LA VERGNE CRUDE OIL ENGINES

REFRIGERATING MACHINERY ICE MACHINES

TYPE "FH" CRUDE OIL ENGINE



GUARANTEED:

To operate on the cheapest and heaviest grades of petroleum and crude oils, including those from the California and Texas fields with an asphaltum base.
To deliver the full rated Brake Horse Power not only at sea level but up to 5000 ft. altitude.
To consume not more than the following quantities of fuel per BHP hour:—

When running at ¾ to full load.......................................0.5 lbs.
" " at ½ to ¾ " ....0.65 "
" " at ¼ to ½ " ....0.75 "

Operates at medium pressures.

Not more than 1½ gallons of lubricating oil per 1000 BHP hours ordinarily required.

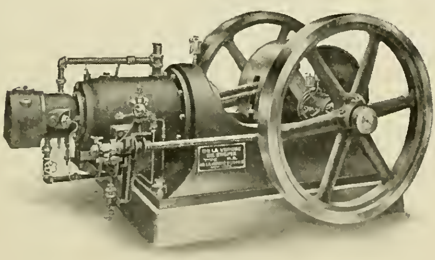
Not more than 3 gallons of cooling water necessary per BHP hour.

Reliable and satisfactory service with minimum expense for upkeep.

Manufactured in sizes of 60 HP. and over.

Detailed information in bulletin No. 112.

TYPE "HA" OIL ENGINE



GUARANTEED:

To operate satisfactorily on ordinary grades of distillates and fuel oils. To deliver the full rated Brake Horse Power. To consume not more than the following amounts of fuel per BHP hour:

When running at full load................ .9 lbs.

When running at ¾ load................1.12 "

When running at ½ load.......................................1.35 "

In sizes from 10 HP. to 100 HP.

For detailed information see bulletin No. 111.

Both types are adapted to and used in all classes of service where reliability is of importance in addition to

Low Cost of Operation.

THE SMITH GAS POWER COMPANY

LEXINGTON, OHIO

GAS PRODUCERS FOR POWER AND HEATING, SUCTION AND PRESSURE TYPES, SPECIAL DESIGNS FOR ANTHRACITE, BITUMINOUS AND LIGNITE COAL. TAR EXTRACTORS AND GAS CLEANING PLANTS.

STANDARD APPARATUS IS BUILT IN FOUR TYPES: B, BF, C AND E.

Type B.	Built in nine sizes.	From 50 to 300 H.P.	for Anthracite and Bituminous coal.
Type BF.	" " " "	" 50 " 300 "	" Bituminous coal only.
Type C.	" " " "	" 50 " 300 "	" Lignite.
Type E.	" " eleven "	" 25 " 300 "	" Anthracite only.

SPECIAL FEATURES OF THE DIFFERENT TYPES

Type B Producers are up-draft equipped with mechanical scrubbers. They are designed to produce a minimum of tar and a maximum of high heat value gas of uniform quality.

Type BF Producers are the same as Type B but have the Type F tar extractor instead of the mechanical scrubber. This tar extractor has no moving parts and the tar is removed without the use of water. Any desired degree of gas cleanness may be secured, but in ordinary practice one milligram of total non-gaseous impurities per cubic foot is considered clean enough for use in engines.

Type C Producers are down-draft equipped with the Type F Tar Extractor. The design is such that nearly all of the volatile contained in the lignite is converted into a fixed gas. It is not necessary to shut down for cleaning. Many plants in service ranging from 50 to 1600 H. P. in capacity.

Type E Producers are up-draft equipped with static baffle scrubbers only.

SPECIAL FEATURES COMMON TO SMITH PRODUCERS OF ALL TYPES

Patented automatic method of regulating the ratio of steam to air in the blast at all loads.

Flat swinging grates in smaller sizes—shaking grates mechanically operated in larger sizes. Special facilities provided for removing ash from center of fire.

Low driving rate per sq. ft. of grate area so that the temperature of the fire will not reach the fusing point of the ash.

Deep fuel bed enables the producer to respond to sudden fluctuations in load.

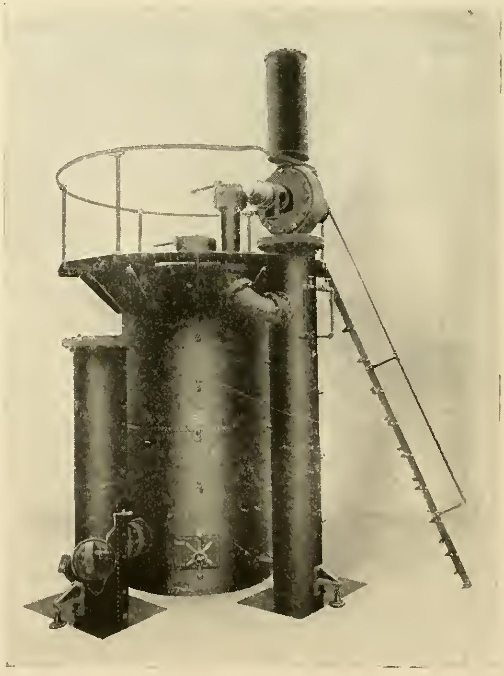
Large fuel magazine obviates the necessity of frequent charging.

Charging Hopper design that prevents the admission of air to the top of the producer while charging.

The Static Baffle Scrubber is efficient, compact, and "fool proof."

Patented self-cleaning producer gas valves.

Exhausters and automatic pressure regulators furnished when it is desired to deliver gas under pressure to engines or for heating.



Smith Type B Suction Producers to operate on bituminous fuel

E. KEELER COMPANY

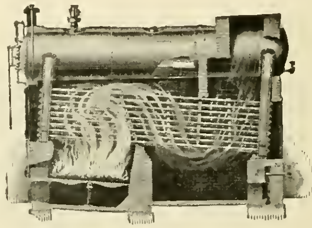
Established 1864

WILLIAMSPORT, PA.

New York Philadelphia Pittsburgh Chicago New Orleans Dallas San Francisco

WATER TUBE, TUBULAR AND MARINE BOILERS, STEEL PLATE WORK

WATER TUBE BOILERS
Standard Type



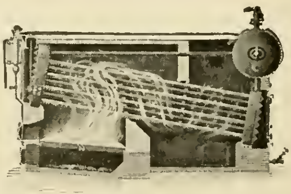
Standard Type Water Tube Boiler

The arrangement of furnace, tubes, headers and drum in the Keeler Water Tube Boiler is efficient, accessible and compact. The superior efficiency of the Keeler Boiler rests upon correct proportions of heating and grate surface for the character of fuel to be burned, ample height of furnace, a superior arrangement of baffle walls and a perfect circulation. Every portion of the heating surface is accessible for both external and internal inspection, making it impossible for soot or scale to accumulate undetected. There is ample room between tubes and drum for inspection or repairs. Special side cleaning doors make it possible to observe the condition of the outside surface of the tubes. There is no part of the interior surface that cannot be examined and cleaned.

Keeler Water Tube Boilers are usually built complete and tested in the shop. This reduces the cost of erection, as the boilers are handled as a unit. It also eliminates the dangers due to careless assembling of boilers in the field and makes the erection merely a matter of placing in position and attaching fittings.

Boilers of 500 H. P. and more must be shipped in a knocked down condition. We are prepared to send erecting engineers to any part of the country to rivet the drums to the headers, expand the tubes and test.

WATER TUBE BOILERS
Cross Drum Type



Cross Drum Type Water Tube Boiler

The Keeler Cross Drum Water Tube Boiler is a modification of the standard design, only in the length and location of the drum and the method of connecting it to the headers. This type was developed to meet the demand for a high grade water tube boiler that could be installed in Office Buildings, School Houses, Churches, Apartment Houses, Hotels and boiler rooms generally where ceiling height is limited or where the boiler must be introduced through narrow passageways or restricted openings.

The pressure parts of the boiler are shipped in a knocked down condition, making it possible to install it without cutting through walls and floors in locations that would be wholly inaccessible for almost any other type of boiler. If boilers are to be exported, the cross drum boiler can be handled at much less expense by steamship companies on account of its reduced bulk in a knocked down condition, and the comparatively small weight of the heaviest piece.

HORIZONTAL RETURN TUBULAR BOILERS

Horizontal Return Tubular Boiler

Our Return Tubular Boiler is the product of fifty years' experience of boiler building. Tube holes are drilled from the solid plate, and not punched small and reamed to size. All seams are thoroughly caulked on the outside, and the end of butt straps are caulked on the inside. Braces are drop forged. Steam outlets, man hole plates, yokes and brackets are of pressed steel.

JOHN MOHR & SONS

349-359 W. Illinois St. CHICAGO, ILL.

GARBE WATER TUBE BOILER, BLAST FURNACES, STEEL LADLES, HOT STOVES, CUPOLAS, FURNACES, MIXERS, CONVERTERS, STERILIZERS, ETC.

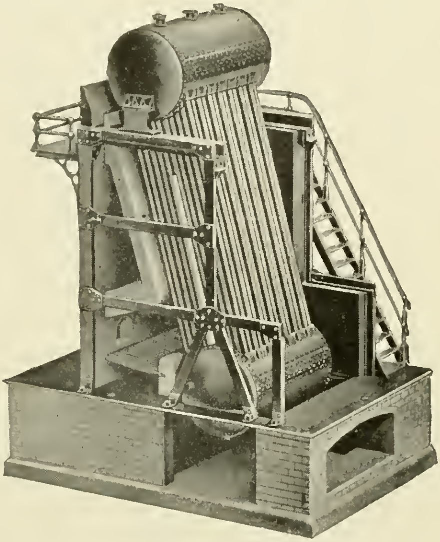
THE GARBE BOILER

Special Advantages

All handholes with their troublesome and expensive gaskets are eliminated, as the tubes are expanded into very large drums which are equipped with the patented pressed "Garbe" Plate. Any tube can easily and quickly be inserted, removed and replaced without disturbing any of the others.

Elimination of all flat surfaces, stay bolts and braces. All parts of Boiler are cylindrical and curved.

All tubes are absolutely straight and nearly vertical, therefore the entire circumference of tube is directly exposed to the gases. The effective heating surface is materially larger than that obtained by horizontal tubes.



Garbe Patent Water Tube Boiler

The upper drum is suspended from a substantial structural frame work, absolutely independent from the mason work; The lower drum is in contact with two slides or guides, thereby allowing free expansion of tubes, equalizing the strain between drums and reducing chances of leakage to a minimum.

The vertical arrangement of tubes allows the steam to develop very freely and to flow by the shortest way possible without changing direction to the upper drum, thereby causing a very rapid circulation. The tubes are distributed over the full length of the Boiler, thus giving a large and uniform steam liberating surface, equal to the full area of the tubes. This vertical arrangement of tubes will do away with local overheating and consequent rupture of the tubes so often occurring in horizontally arranged tubes.

Soot, dust and ashes cannot accumulate on tubes or any part of drum, thereby allowing longer periods of operation without the necessity of cleaning.

Large water capacity, due to the extremely large size of upper and lower drum, insuring a more constant water level than any other Boiler.

The feed water passes through the rear bank of tubes, which have the lowest temperature, to the lower drum and deposits therein all impurities.

Over half of the entire heating surface is effective in liberating steam.

Practically no scale in tubes owing to rapid circulation and vertical tubes.

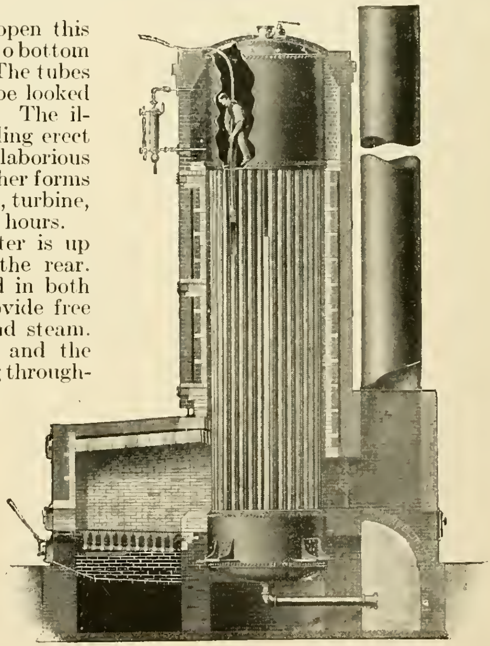
THE WICKES BOILER COMPANY

SAGINAW, MICHIGAN, U. S. A.

VERTICAL WATER TUBE BOILERS; HIGH GRADE RETURN TUBULAR BOILERS

These boilers are designed for delivering dry steam, for very easy cleaning and for high every-day thermal efficiency. The illustration gives a clear idea of the design, which consists, primarily, of upper and lower drums joined by perfectly straight boiler tubes.

The steam drum is arranged to give a height of 66" from water line to the dished head, upon which the steam outlet nozzle is riveted. This high drum serves several purposes. It provides room for separation from the steam of water which is always entrained with steam at a point close to the surface of liberation; it gives room for workmen to stand inside of the boiler when cleaning the tubes, and since the shell is subject to a mild degree of heat some superheat is effected upon the steam.



Two 12" x 16" manholes open this boiler, it is accessible from top to bottom for inspection and cleaning. The tubes are straight; every tube can be looked through, washed or scraped. The illustration shows a man standing erect using a turbine cleaner. Is it laborious compared with the work in other forms of boilers? Two men can open, turbine, close and fill this boiler in ten hours.

The circulation of the water is up the front tubes and down the rear. The tube area is made equal in both sets of tubes in order to provide free circulation both for water and steam. Steam pockets cannot form and the arrangement equalizes heating throughout the boiler.

The blow-off is located at the very lowest point of the bottom of the mud drum. Feed water is usually introduced into the steam drum directly into the down-take tubes far below the water line.

The furnace is of the external oven type, the grate surface being entirely surrounded by highly heated surface in order to avoid chilling the products of combustion. Any type of stoker may be applied to the furnace.

The gases in their flow from furnace to outlet are compelled to sweep over heating surface in every foot of their travel; every foot of heating surface in the boiler is swept over by the gases in their travel. The gases are closely enough confined to the heating surface to entirely surround and cover it, as well as establish a strong scrubbing action of gas to metal. No chance for gases to short-circuit exists. No chance for gases to enter pockets in the setting unfilled with heating surface exists. A very long gas travel is provided. The design provides for the very best heat transfer by conduction and convection.

The tubes being vertical, soot and dust carried on gases and impurities precipitated from the water fall to the mud drum, where easy removal is provided for.

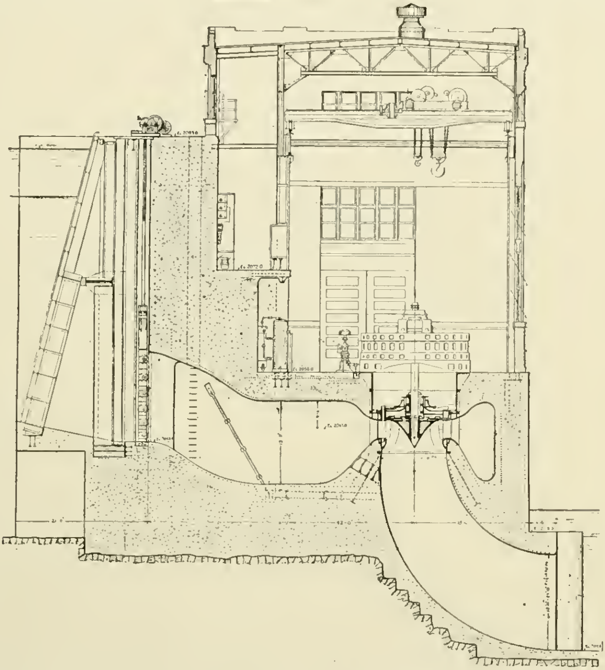
The boiler is constructed of the very best homogeneous steel, made by the open hearth process. The highest character of workmanship known to the art at the present day is put upon these boilers. The closest scrutiny and inspection by the best informed on this workmanship is invited and requested.

I. P. MORRIS COMPANY

HYDRAULIC DEPARTMENT

PHILADELPIA, PA.

SPECIALISTS IN THE DESIGN AND CONSTRUCTION OF HIGH CLASS, HIGH POWER AND HIGH EFFICIENCY HYDRAULIC TURBINES



Cross section through one 6,000 horse-power turbine in Development No. 2 Power House, Appalachian Power Company, Virginia. Total equipment furnished this Company consists of seven turbines with I. P. Morris governors. Careful efficiency tests made by the Consulting Engineers of the Power Company, Messrs. Viele, Blackwell & Buck, show the average of the maximum efficiencies of two of the units to be 93.7%, clearly indicating the advisability of using the single runner, vertical shaft turbine for low heads.

Among the contracts for turbines of this type recently awarded to the I. P. Morris Company may be mentioned:

Appalachian Power Company, New River, Va.:

Station No. 2

4—6,000 H.P. turbines, head 49 feet, speed 116 R.P.M.;

Station No. 4

3—3,500 H.P. turbines, head 34 feet, speed 95 R.P.M.;

Mississippi River Power Company, Keokuk, Iowa:

8—10,000 H.P. turbines, head 32 feet, speed 57.7 R.P.M.

J. G. White & Co., Stevens Creek Development, Georgia:

5—3,125 H.P. turbines, head 27 feet, speed 75 R.P.M.

Alabama Power Company, Coosa River, Alabama:

4—17,500 H.P. turbines, head 68 feet, speed 100 R.P.M.

Cedar Rapids Mfg. & Pr. Co., St. Lawrence River, Canada:

9—10,800 H.P. turbines, head 30 feet, speed 55.6 R.P.M.;

3—1,500 H.P. turbines, head 30 feet, speed 150 R.P.M.

Laurentide Company, Ltd., Grand Mere, P. Q., Canada:

6—20,000 H.P. turbines, head 76 feet, speed 120 R.P.M.

Total capacity of turbines built or under construction by I. P. Morris Company, 1,586,735 horse-power, of which turbines aggregating 711,735 horse-power were contracted for during the last eighteen months.

GREEN ENGINEERING CO.

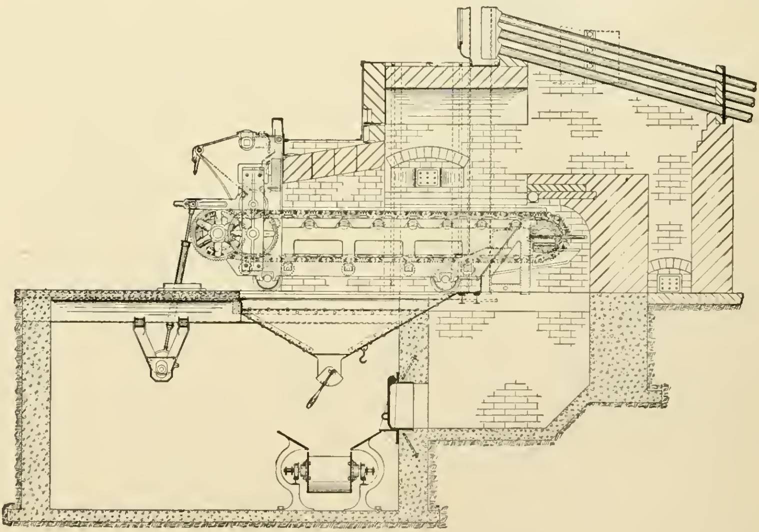
CHICAGO ILLINOIS

MANUFACTURERS OF GREEN CHAIN GRATE STOKERS; GECO RATCHET ASH DRAGS; GECO PRESSURE WATERBACKS; GECO PNEUMATIC ASH HANDLING SYSTEMS.

GREEN CHAIN GRATE STOKER

The Green Chain Grate Stoker gives in service a practical demonstration of progressive combustion, the fuel being fed in at the front of the furnace and carried at regulated speed to the rear of the furnace, where, as ashes, it drops into the ash pit to be removed mechanically or by hand. Operation is entirely automatic and continuous. The fuel is ignited and coked at the front end of furnace, air is admitted through automatically cleaned air spaces in grate, and smokeless combustion with low grade fuel is produced. It will quickly pick up or drop a heavy load or economically bank the fire. Labor cost for cleaning furnace is low and the cost for repairs minimized.

Green Stoker Applied to a Horizontal Water Tube Boiler

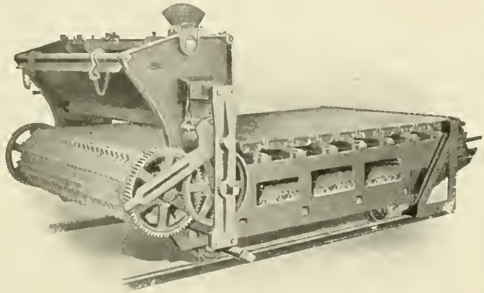


Construction

Two types of grates are made adaptable to any make of boiler. The fire bed may be level or sloping. The side girders of frame are entirely away from the fire and arranged to provide an increased air supply. Heavy cast-iron links, thoroughly ventilated, form the firing bed. These links interlock and automatically clear the air spaces without excessive loss of fine coal. The rear cross girder is fitted with a heavy plate on under side upon which ashes accumulate and, in connection with the members just above and below, prevent the passage of air around rear portion of grate, where ashes discharge; and this is further supplemented by dampers, which prevent the leakage of air past the side frames or below the lower part of the chain.

GREEN CHAIN GRATE STOKER

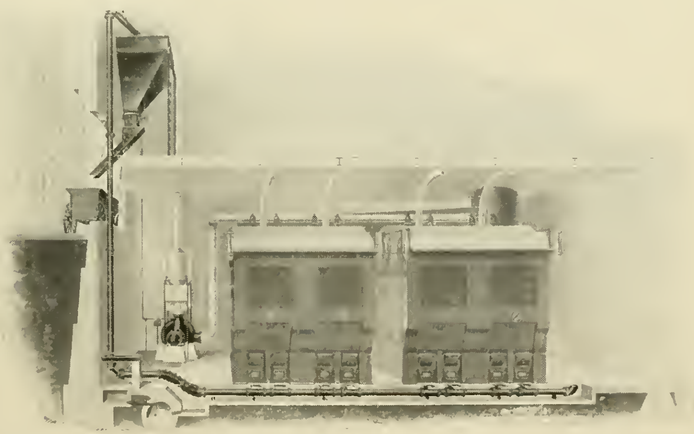
The grates are built in any width and in lengths from 9 ft. up to 12 ft. deep. Driving mechanism consists of ratchet, cast-steel pawls and cast-steel spur gear train babbitted in a special self-contained frame independent of, but bolted to the stoker front side frame. Quick adjustment may be had over a wide range and the source of power may be either above or below the boiler-room floor. A regulating feed-gate permits hard firing and is provided with an easily renewable tile lining, which prevents injury to the gate by fire eating back into coal hopper. The igniting arch is adaptable to any width furnace and easily renewable at low cost. It is flat, ventilated, and it gives uniform ignition the full width of the furnace and allows local repairs at any point without undue loss of use of the boiler.



Stoker Withdrawn From Setting

GECO PNEUMATIC ASH HANDLING SYSTEM

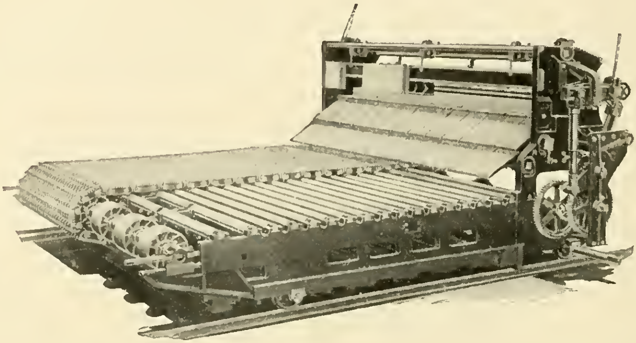
This system consists of a conveyor pipe located convenient to ash pits and provided with openings into which ashes are readily hoed. An air current of high velocity instantly carries the ashes to a separator and storage tank. On entering tank the ashes are automatically sprayed, thoroughly quenched, separated from air and deposited. An exhauster produces the air current. Tank may be readily emptied by gravity into carts, or cars. One man operates system.



(See also next page)

(Continued from preceding pages)

GREEN ENGINEERING COMPANY



"L"-TYPE GREEN CHAIN GRATE STOKERS

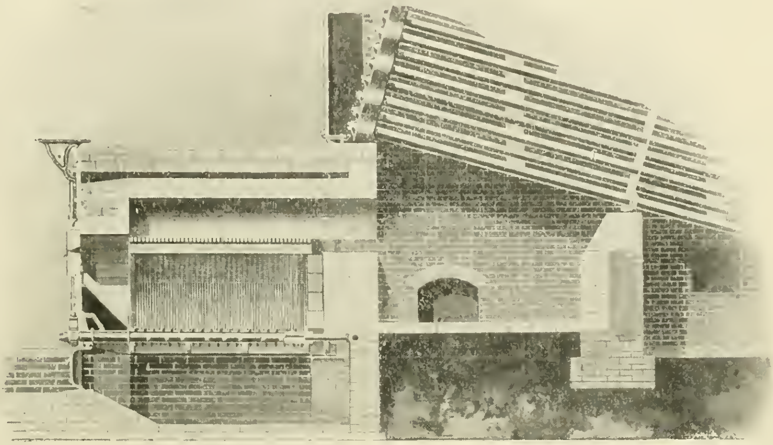
The advantages of automatic operation of chain grate stokers have been enviously hoped for by users of low volatile coal for many years, as no other type of stoker can be operated as cheaply or with such uniformly continuous high economy and high capacity.

"L"-Type Green Chain Grate Stokers provide facilities for treating low volatile coals when introduced into the furnace to force their proper ignition and prepare them for complete combustion thereafter. The facilities provided are all automatic, simple, effective, and through wide range, making the apparatus flexible.

The burning of low volatile coal having several constituents is a complex problem of thorough ignition, and in "L"-Type Green Chain Grate Stokers, is solved by three distinct and progressive stages. The first subjects the fuel to radiated heat, liberating and igniting its volatile constituents, a process accompanied by a caking tendency, resulting from the deposit of tarry constituents onto the remaining fuel. The second stage prevents this caking by agitation of the fuel while complete coking without combustion, that is, without introduction of air, is taking place. The third stage begins with the deposit of entirely coked and ignited fuel onto the chain grate surface in a porous, fragmentary condition, permitting the passage there through of ample uniformly distributed air supply. Under these conditions, combustion is readily completed before discharge of the ash. All these processes and operations are automatically performed and can be maintained continuously after the various adjustments provided in the apparatus have been properly set for the particular fuel to be used.

The successes made with over 50,000 H. P. in operation since the introduction of these stokers, bear out the correctness of the theory, design and practical operation of "L"-Type Green Chain Grate Stokers.

MURPHY IRON WORKS



Murphy Furnace—Dutch Oven Setting

At either side of the furnace extending from front to rear is the coal magazine into which the coal may be introduced either by hand or mechanically. At the bottom of this magazine is the coking plate against which the inclined grates rest at their upper ends. The stoker boxes, operated by segment gear shafts and racks, push the coal over the coking plate and onto the grates. The grates are made in pairs, one fixed and the other movable. The stationary grates, at their lower ends, rest on the grate bearer, which also acts as a support for the clinker grinder. The clinker grinder consists of a square steel shaft, onto which is slipped small cast iron toothed segments, which are readily replaced in case of breakage. Just over the coking plate is the arch plate, from which a fire brick arch is sprung over the entire furnace. Upon this arch plate are cast numerous ribs to form a series of air ducts immediately over the coking plate, conveying the heated air from the chamber above the arch into the combustion chamber. This arch plate also forms the wall of the magazine. The furnace, or battery of furnaces, can be operated by a small automatic engine, motor or by overhead shaft and ratchet drive, as may be desired. Arrangement is made for exhaust steam connections at the lower end of the grates for the protection of this portion of the grates and clinker grinders and for the softening of the clinker. In connection with horizontal tubular boilers or water tube boilers horizontally baffled, the Murphy furnace can be installed with a flush front setting. Arrangement can be made for extended or Dutch oven settings, should this be desired.

WM. BARAGWANATH & SON

CHICAGO, ILLINOIS

FEED WATER HEATERS, PURIFIERS, CONDENSERS, COOLING TOWERS, SEPARATORS

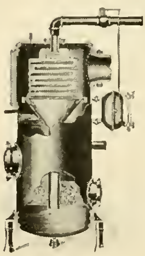
FEED WATER HEATERS, STEAM JACKETED TYPE

(Vertical, Horizontal and Inverted)

In the STANDARD TYPE as here illustrated the steam enters the bottom, passes up through the tubes, and returns down the annular space between the inner shell and the jacket. The water is fed through the side near the bottom and passes to the boiler through the side outlet at the top. The steam jacket prevents radiation of heat from the water, and a higher degree of heat can be obtained than with any other closed heater made. Properly proportioned drips, blow offs, and hand holes are provided.

THE INVERTED TYPE is the same in all respects as the STANDARD TYPE, except that the steam enters and leaves at the top.

THE HORIZONTAL TYPE is designed for use in low basements and for marine service. It has all of the advantages of the STANDARD TYPE and is widely used where structural conditions make the use of the vertical type impossible or unadvisable. All types built in sizes from 50 H. P. up.



VERTICAL STEEL OPEN HEATER

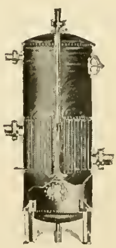
(With Filter)

This HEATER is especially suited for use in muddy water. Also in connection with heating systems, acting as a receiving tank.

The water inlet is sealed. The water flows over a series of cast iron trays, then passing through a down pipe into the settling chamber in the bottom of the heater, from which it filters upwards through the filtering chamber to the pump supply.

An outside connected float operates a balanced valve on the supply pipe.

The pans are readily removable through a large door, provided for that purpose. Built in sizes from 50 H.P. up.



VERTICAL HOT WATER HEATER

This HEATER is designed especially for heating water for domestic purposes and is particularly adapted to hotels, restaurants, laundries and other buildings requiring large quantities of hot water.

The natural circulation through the central tube is accelerated by the flow of incoming cold water, creating a strong circulation and making both upper and LOWER water chambers reservoirs of HOT water, thus providing against a sudden demand for the maximum requirements for hot water.

The manholes provided in both water chambers allow easy access for cleaning and inspection. Built only to order.

BAROMETRIC CONDENSERS

THE BARAGWANATH BAROMETRIC CONDENSER is simple, reliable and economical. It is always set at an elevation (usually 33 ft.) above the hot well, so that the height of the column of water in the tail pipe is sufficient to clear itself automatically of the water and air it contains.

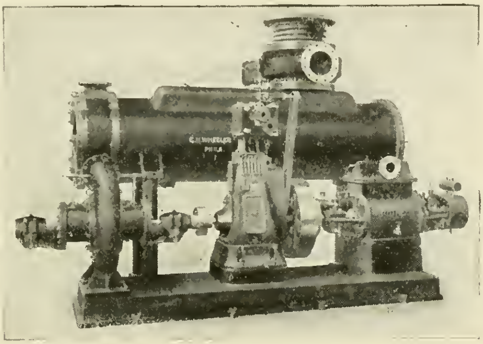
It is applicable to any purpose requiring a vacuum, and is used on engines, pumps, and vacuum pans with equal success. Except under special conditions of leaky connections, or very high vacuum requirements, no air pump is used.

C. H. WHEELER MANUFACTURING COMPANY

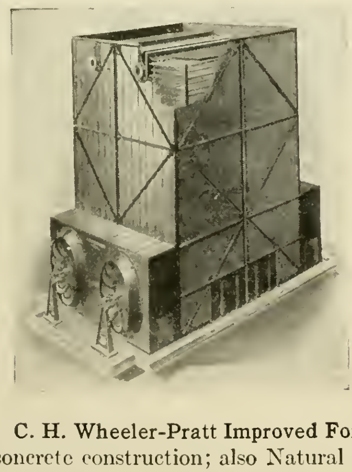
Main Office and Works PHILADELPHIA, PA.

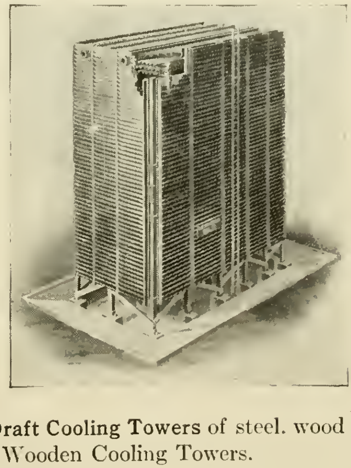
HIGH VACUUM APPARATUS FOR STEAM TURBINES: Surface, Jet and Barometric Condensers. Water Cooling Towers of the Forced and Natural Draft designs. Vacuum Pumps of the Reciprocating, Rotary and Hydraulic Entrainment High Speed types. Centrifugal Pumps—motor, engine, turbine and belt driven. Closed Feed Water Heaters. Special Turbine Exhaust Gate Valves. Copper Expansion Joints. Multiflex Atmospheric Exhaust Valves.

"EVERYTHING BUT THE TURBINE"



HIGH EFFICIENCY SURFACE CONDENSING EQUIPMENT consisting of a C. H. Wheeler Improved Surface Condenser with ROTREX Vacuum Pump and Centrifugal Circulating Pump, both mounted on a common base plate and direct connected to a Vertical Enclosed Self Lubricating Engine.





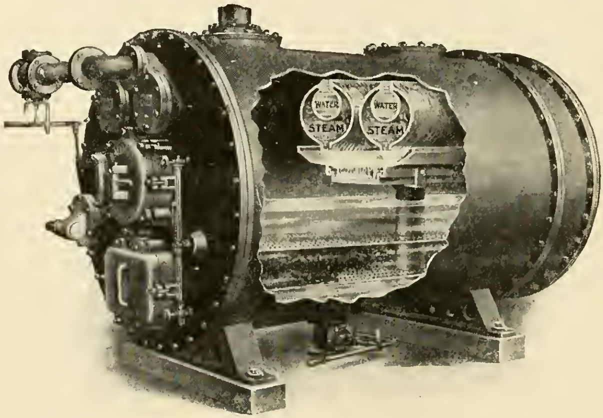
C. H. Wheeler-Pratt Improved Forced Draft Cooling Towers of steel. wood or concrete construction; also Natural Draft Wooden Cooling Towers.

THE NATIONAL PIPE BENDING CO.

Boston Office	Main Office and Works	New York Office
54 High Street	NEW HAVEN, CONN.	149 Broadway

THE NATIONAL COIL OR CLOSED FEED-WATER HEATER. THE NATIONAL DIRECT CONTACT FEED-WATER HEATER AND PURIFIER. NATIONAL STORAGE HEATERS. NATIONAL STEAM AND OIL SEPARATORS. COILS AND BENDS OF IRON, BRASS AND COPPER PIPE.

THE NATIONAL
DIRECT CONTACT FEED-WATER HEATER AND PURIFIER



In the Direct Contact (open type) Heater, the feed water is brought to high temperature by direct and actual contact with the exhaust steam, then freed from those impurities which are precipitated by heating, and lastly, filtered before flowing to the pump. It combines in one apparatus a Heater, Purifier, Storage, Reservoir and Oil Separator.

The water enters through a regulating valve and is distributed to the smaller or inner pipes which extend the full length of the heater. Overflowing the port at the top, it passes as a thin film over the entire outer surface of the large pipe. During this time it is warmed by the steam in the steam pipe which practically surrounds the water pipe. The exhaust steam after passing through a National oil separator, which forms a part of the heater, escapes from the steam pipe through the port at the bottom and in passing through the curtains of water heats it by actual contact to highest possible temperature.

The heated water collects in the tray beneath the pipes and by means of a vertical pipe reaches the bottom of the heater where the scale-forming substances are precipitated. The water then passes upward through the filter material to the hot storage chamber from which the pure hot water flows direct to the pump.

Upward filtration has these advantages: the filtering material needs cleaning or renewal only at long intervals because most of the solids separate out below it, relieving the filter bed of all unnecessary work; in case the perforated plates supporting the filtering material should break, the material will not be carried over to the pump, as would be the case with downward filtration.

A quick-opening blow-off valve at the bottom of the heater affords opportunity to clean the filter bed by reversing the flow.

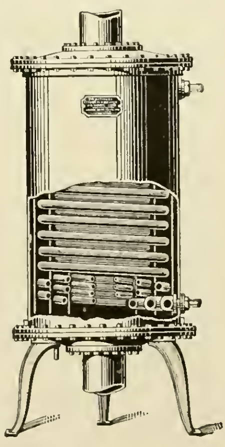
THE NATIONAL PIPE BENDING CO.

THE NATIONAL OIL SEPARATOR

Patent applied for

This gravity-type oil separator absolutely removes all grease or cylinder oil from exhaust steam so that the condensation may be used for feeding boilers, in laundry or dye-house service, ice making, or for similar purposes. It has a multi-ported baffle plate, each port having an individual baffle, a distinctive feature found only in the National Separator. The large capacity of this separator not only insures effective separation of oil from exhaust steam but also overcomes the pulsations of exhaust, giving an even flow of steam.

NATIONAL CLOSED FEED WATER HEATER



For use when the feed water need not be purified. In the National, the feed water is heated while being pumped through a coil of seamless-drawn brass or copper tubing surrounded by exhaust steam. The water is absolutely free from even a trace of oil, for it does not come in contact with the exhaust steam. The brass or copper has no effect on the water.

The enclosing shell is of cast-iron or steel plate; it lasts indefinitely because the feed water cannot reach it.

The economy resulting from the utilization of exhaust steam varies from 8 to 13 per cent of the coal burned, depending on conditions—temperature of feed water and boiler pressure; but other advantages are reduction of strains caused by feeding cold water, and increase in boiler capacity.

The National is safe—the coils are tested to 600 pounds water pressure, and the shell is subjected to exhaust pressure only.

More than 3,250,000 horse power of these heaters have been installed.

THE UNITED STATES GRAPHITE CO.

SAGINAW, MICH., U. S. A.

MINERS OF GRAPHITE AND MANUFACTURERS OF GRAPHITE PRODUCTS

U. S. G. CO.'S MEXICAN BOILER GRAPHITE

This Graphite, when introduced in the boiler feed, works through and beneath the already formed scale and loosens it so that it either sloughs off or may be easily removed.

Then by mingling with the scale making elements present to some extent in all feed waters, the graphite keeps the formation soft and easily removable; it sometimes entirely arrests the development of scale.

U S G Co.'s Mexican Boiler Graphite does this work by mechanical action. It has no chemical effect, cannot cause foaming, and under normal conditions cannot be carried out with the steam.

U S G Co's Mexican Boiler Graphite, on account of its mechanical action, is effective in any feed water regardless of its character, and therefore saves the trouble and expense of frequent analyses.

Put up in barrels (about 400 pounds) and in 100 pound drums.

Those interested should send for testimonials and for Booklet "L" which goes into the subject thoroughly.

U. S. G. CO.'S No. 205 LUBRICATING GRAPHITE

There are two formations of graphite: crystalline or "flake" and amorphous or "powdered."

Flake graphite, no matter how finely pulverized, remains always in the form of mica-like flakes and is, as a matter of fact, incapable of really fine pulverization—which makes its presence in high grade lubricants undesirable.

Amorphous graphite, on the other hand, is susceptible of reduction to a powder of impalpable and gritless fineness and is of a nature to combine intimately and permanently with oils and greases.

"NO. 205" is the powdered kind of graphite—air-floated, absolutely gritless and accordingly vastly superior to the coarser grained and less finely pulverized "flake" graphite. It cools hot bearings while the machinery is running and then keeps them cool. Saves shut downs, time and trouble. For twenty cents in stamps to pay postage we will send once only, a one pound can with full directions.

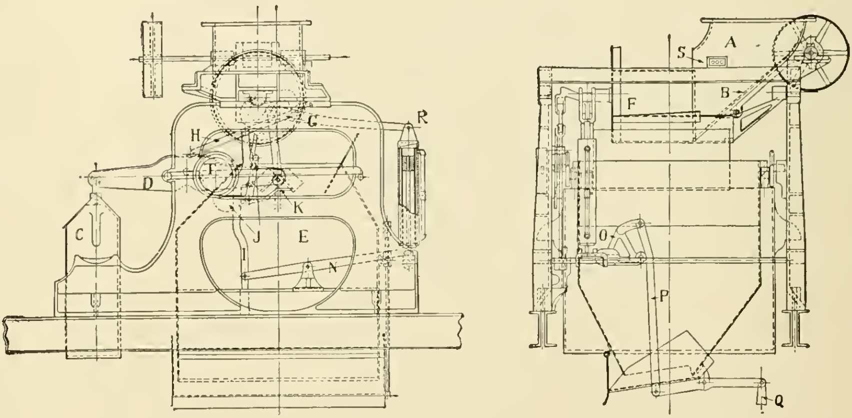
RICHARDSON SCALE COMPANY

Head Office and Works, 17 Colfax Ave., PASSAIC, N. J.

New York: 14 Park Row Building — Chicago, 209 So. State Street

BUILDERS OF AUTOMATIC WEIGHING MACHINERY

GRAVITY OPERATED COAL SCALE



The framework is of cast iron. The weigh hopper E, made of or lined with sheet monel metal, is supported on the cast steel beam D, and counterbalanced by the cast iron weight box C, which is loaded with standard dead weights for the required quantity of coal to be weighed. The feed gate F, which is also lined with non-corrosive metal, is opened by means of the pendant X, which is actuated by the beam D. The power to operate is derived from the weights in the box C.

When the exact amount has entered the hopper E, the gate automatically closes, and is locked by the toggle levers H and J. The load in the hopper is emptied by the unlocking of the toggles O and P. The return of the beam and the shock of the weights supported by it are cushioned by means of the counterweight R and the air cushion Z. There are no springs in this scale.

The coal is fed through the chute A, and if it is soft coal a reciprocating plate feeder B worked by an eccentric evenly feeds the coal through the gate F into the hopper E.

The machine is self-testing, and the beam balances on every draft.

THE RICHARDSON AUTOMATIC WEIGHING MACHINERY

The scale described above is built in sizes having the following hopper capacities: 100, 200, 300, 500, 1000, 1500, 2000 and 3000 lbs., the corresponding hourly capacities being: 4, 8, 15, 25, 50, 75, 100 and 150 tons.

This machine is largely used in suitable sizes, for weighing coal as received in power stations and for checking coal as delivered from overhead bunkers either to mechanical stokers or to the boiler room floor.

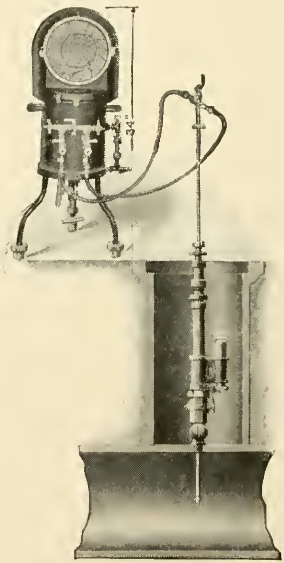
We also supply THE MERRICK PATENT WEIGHTOMETER or Conveyor Scale, and an Automatic Water Scale.

We have been building these scales for the past twenty-five years, and many notable installations and repeat orders testify as to their reliability.

SIMPLEX VALVE AND METER COMPANY

PHILADELPHIA, PA.

WATER METERS OF VENTURI AND PITOT TUBE TYPE, RATE OF FLOW CONTROLLERS, LOSS OF HEAD, RATE OF FLOW AND WATER LEVEL GAUGES, ALTITUDE VALVES FOR RESERVOIRS AND RAILROAD WATER TANKS, AUTOMATIC AIR AND VACUUM VALVES, CHEMICAL FEED DEVICES AND OTHER HYDRAULIC APPARATUS OF SPECIAL DESIGN.



The Simplex type "G" register is adapted for use with Venturi tubes and with pitot tubes. For this latter purpose it is furnished in both stationary and portable form. The illustration shows the portable type.

This recorder is particularly useful in making leakage surveys in a water works system, or testing the flow through any size pipe. The charts are graduated in velocity in feet per second. The tap and pipe connections are one inch in diameter. The instrument will record all flows from half a foot per second up to ten feet per second, or any desired maximum.

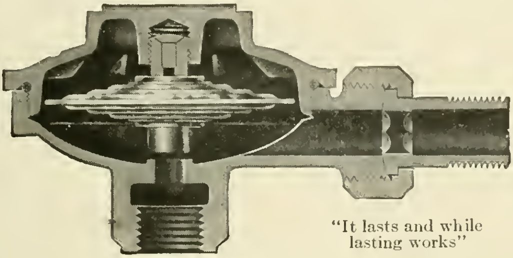
In the stationary form the instrument is well suited for use as a pumping station meter, where it is impossible to install a Venturi tube.

C. A. DUNHAM COMPANY

MARSHALLTOWN, IOWA

NEW YORK: NO. 1 MADISON AVE. CHICAGO: 343 S. DEARBORN ST.
SAN FRANCISCO: 602 MONADNOCK BLDG.
CANADIAN FACTORY AND OFFICE: TORONTO, ONTARIO

MANUFACTURERS OF THE DUNHAM RADIATOR TRAP, THE DUNHAM BLAST TRAP, THE DUNHAM AIR VALVE AND THE DUNHAM VACUUM AND VACUO VAPOR SYSTEMS OF HEATING.



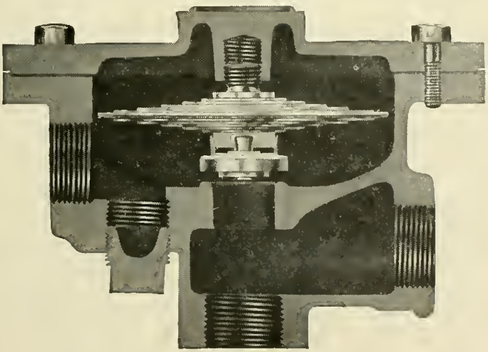
"It lasts and while lasting works"

The Dunham Radiator Trap

THE DUNHAM RADIATOR TRAP

for use in connection with the Dunham Vacuum and Dunham Vacuo Vapor Systems of Steam Heating. It will positively allow for the complete discharge of water and air from the radiator to which it is attached without loss of steam. Constructed of phosphor bronze.

Made in four patterns—Right hand, left hand, straight way and angle.
Size connections—½ inch pipe. Capacity—350 sq. ft. direct radiation.
Maximum steam pressure—10 lbs. Wt. 2½ lbs.



The Dunham Blast Trap

Size	Capacity	Connection	Wt.
¾″	1500 sq. ft. direct radiation	¾″ pipe	13 lbs
1″	3000 " " "	1″ pipe	21 "

THE DUNHAM BLAST TRAP

for use in draining blast coils in vacuum or other steam heating systems. Also for use on large direct radiating units where the Dunham Radiator Trap is too small. Positively opens for water and air and closes for steam. Body made of cast iron.

Care must be taken in reducing blast surface to equivalent direct by multiplying by a factor ranging from 3 to 9, depending upon the temperature, velocity and volume of air being forced over the coils.

THE DUNHAM AIR VALVE

This valve is made for use in revamping both old and new air-line jobs. It is built upon the same principle as the Dunham Radiator Trap. Is made of cast bronze, nickel plated all over and has union nut and nipple. Made for ⅛ inch pipe connection. Architects and engineers can specify this valve with the positive assurance that it will give service without necessitating the attention that is required to keep so many other air line valves in working order.

DUNHAM VACUO VAPOR SYSTEM

is simply a low-pressure system of heating that works upon pressure, vapor, and vacuum, without necessitating the use of a vacuum pump. It is particularly applicable to residence, apartment house, and church heating where low pressure (below 2 lbs.) boilers are used.

Complete information, catalog and prices will be sent on application.

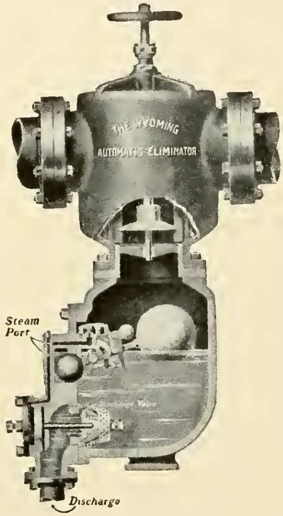
The Dunham System is installed in such buildings as the Woolworth Bldg.; N. Y.; 80 Maiden Lane Bldg., N. Y.; Insurance Exchange Bldg., Chicago; Sherman Hotel, Chicago, and hundreds of other buildings all over the country.

W. H. NICHOLSON & CO.

WILKES-BARRE, PA.

MANUFACTURERS OF THE WYOMING ELIMINATOR AND THE WYOMING STEAM TRAP.

THE WYOMING AUTOMATIC ELIMINATOR



Horizontal Type

This is a combination steam separator and trap, for eliminating water, moisture and impurities from live steam. The separator portion of the HORIZONTAL TYPE has an arrangement of four corrugated baffle plates that has been patented by us. These plates are so placed that the steam in passing through is obliged to make a double "S" turn.

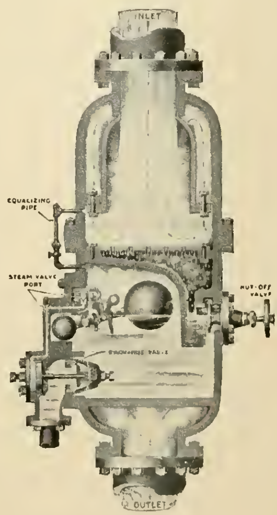
The trap is not what is commonly known as the float operated type. The float is instrumental only in releasing the latch when the water has reached a predetermined level. The ball weight released by the latch causes live steam to be admitted behind the piston. The full steam pressure behind this piston moves it forward and opens the discharge valve instantly. The water passes out and permits the float to fall to its lowest position. The weight of the downward moving float raises the ball weight to its suspended position where it is held by its latch in readiness for the next discharge.

From the illustration of the VERTICAL TYPE it will be noticed that the steam, after entering the separator, impinges against the centre perforated baffle, causing the water, moisture and impurities, with the aid of gravity, to drop to the trap section below. The sudden reversal of direction of steam current, causes all moisture to be thrown out that does not come directly in contact with the perforated plate.

The trap portion is practically the same in both types. The entire machine is compact and, in fact, takes up no more room than the ordinary separator.

The Wyoming is guaranteed to supply steam that is 99.5% dry, and up to as near perfect separation as is possible with a separator, without causing back pressure.

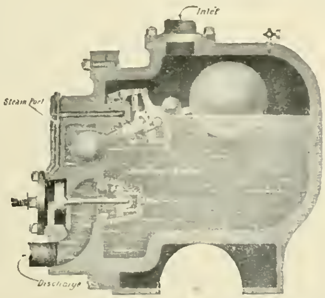
We are prepared to ship promptly such sizes of either the horizontal or vertical type as are suitable for the following diameters of steam pipe: 2½″, 3″, 3½″, 4″, 4½″, 5″, 6″, 7″, 8″, 9″, 10″, 12″, 14″ and 16″.



Vertical Type

W. H. NICHOLSON & CO.

THE WYOMING PISTON OPERATED TRAP



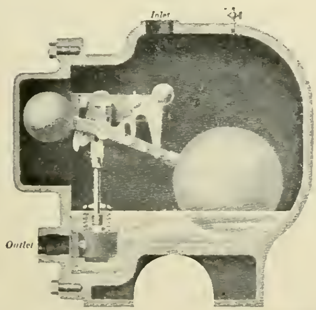
This trap is what might be termed an Automatic Piston Operated Valve. The valve gear is identical with that used in connection with the trap of the Eliminator, incorporating all of the essential features necessary in producing the highest efficiency in a steam trap. The non-wire-drawing, water-sealed, piston operated discharge valve is an approach to perfection in this line. It means a long life for the valve and seat, as it has a quick discharge, not a long drawn out, valve cutting, continuous flow discharge, squeezing through a $\frac{1}{4}$" hole at 100 lbs. pressure.

SIZES AND PRICES

Code Word	Jot	Joy	Jolt	Jove	Jog
Size Number	1	2	3	4	5
Capacity for draining all Condensation from Steam Pipe	1" to 3"	4"–5"	6"–7"	8"–9"–10"	12"–14"–16"
Size of Inlet Pipe	$1\frac{1}{4}$"	2"	$2\frac{1}{2}$"	$3\frac{1}{2}$"	$4\frac{1}{2}$"
Size of Outlet Pipe	1"	$1\frac{1}{2}$"	2"	3"	4"
Size of Discharge Valve Opening	1"	$1\frac{1}{2}$"	2"	3"	4"
Maximum discharge in gallons per hour at 100 lbs. pressure	2400	4200	6500	11520	21000
Approximate Shipping Weight	132 lbs.	260 lbs.	325 lbs.	540 lbs.	575 lbs.
Price	$80.00	$100.00	$116.00	$144.00	$180.00

These Traps Will Operate from 150 lbs. Down to 5 lbs. Pressure.

THE WYOMING WEIGHT OPERATED TRAP



The float is only instrumental in releasing the valve weight, which in dropping, lifts the discharge valve. No dependence whatever is placed upon the buoyancy or weight of the float to lift the discharge valve. The valve weight consists of a levered cast-iron ball, the weight of which governs the capacity or size of hole through the discharge valve seat. It is therefore obvious that by simply increasing the weight of the ball weight a discharge valve of almost any size can be operated. This is the reason why the capacities of the Wyoming are from 50 to 100% larger than others.

Size Number	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Size of Inlet Pipe connections	$\frac{1}{2}$"	$\frac{3}{4}$"	1"	$1\frac{1}{4}$"	$1\frac{1}{2}$"	2"
Will drain lineal feet of 1" pipe	3500	5500	9500	14500	25000	35000
Intended for square feet of radiation surface	1500	2000	3200	5500	12000	24000
Maximum discharge in gallons per hour at 5 lbs. pressure	350	400	780	1560	2000	3100
Maximum discharge in gallons per hour at 100 lbs. pressure	275	310	415	580	750	1200
Dimensions Height	14"	14"	$14\frac{1}{2}$"	$14\frac{1}{2}$"	$18\frac{3}{4}$"	$18\frac{3}{4}$"
Dimensions Width	9"	9"	10"	10"	11"	11"
Dimensions Length	$16\frac{1}{2}$"	18"	17"	20"	$19\frac{1}{2}$"	$22\frac{1}{2}$"
Shipping Weights	122	130	140	150	240	275
List Price	$20.50	$22.50	$28.00	$35.00	$50.00	$70.00

FOR ALL PRESSURES FROM 0 TO 150 POUNDS

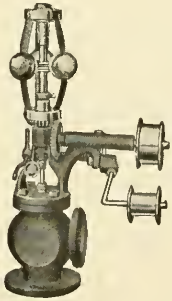
THE PICKERING GOVERNOR CO.

PORTLAND, CONNECTICUT

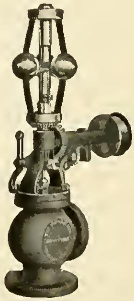
GOVERNORS FOR STEAM ENGINES, GAS ENGINES, STEAM TURBINES, MECHANICAL CONTROL AND POWER REGULATION.

Owing to the absence of joints our Governors are very responsive to slight changes in load, moving quickly and positively into correct position for maintaining the admission of steam proportionate to the duty required of the engine. Absence of joints gives maintenance in efficiency under continued and severe duty.

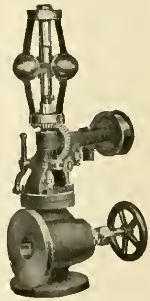
Speed Rangers are incorporated, permitting wide range in adjustment of Engine speed while running.



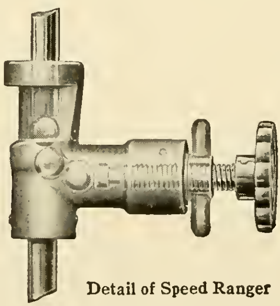
Class A



Class B Vertical



Gov. with Stop Valve



Detail of Speed Ranger

Class A Governors are equipped with safety stop which shuts off steam from the engine if governor drive belt should break. Class B are not equipped with safety stop. Horizontal B is never provided with safety stop. Governor with stop valve does away with joint between governor and valve.

Class B Horizontal

TABLE OF DIMENSIONS, ETC., FOR CLASSES A AND B

Diameter of Opening Size of Governor	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	7	8	9	10
From center of inlet to base...	$3\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$5\frac{1}{16}$	$5\frac{1}{2}$	$6\frac{1}{4}$	$7\frac{7}{16}$	$7\frac{5}{16}$	8	$8\frac{9}{16}$	9	10	$11\frac{1}{2}$	$11\frac{1}{2}$
Extreme Height..............	$20\frac{3}{16}$	$23\frac{31}{32}$	$25\frac{3}{32}$	$27\frac{1}{4}$	$27\frac{13}{16}$	$32\frac{5}{16}$	$33\frac{15}{16}$	$41\frac{5}{32}$	$41\frac{5}{32}$	$46\frac{1}{2}$	$49\frac{1}{8}$	$49\frac{3}{8}$	$53\frac{7}{8}$	$55\frac{7}{8}$	$60\frac{3}{4}$
Extreme expansion of Balls..	7	8	8	9	9	10	10	13	13	15	$16\frac{1}{2}$	$16\frac{1}{2}$	18	20	20
Speed of Governor..........	350	380	380	300	300	340	340	320	320	275	275	275	260	260	225
Dia. of Pulley on Gov.......	$2\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	4	4	5	5	5	6	7	7	8	8
Dia. of Cyl. 300 ft. Piston Sp..	6	7	9	10	12	14	16	18	20	22	26	31	36	40	45
" " " 400 " " "	5	6	8	9	10	12	14	16	18	20	23	27	31	35	39
" " " 500 " " "	$4\frac{1}{2}$	5	7	8	9	10	12	14	16	18	21	24	28	31	35
" " " 600 " " "	4	$4\frac{1}{2}$	6	7	8	9	11	13	15	16	19	22	25	28	32

For complete table and for sizes below $1\frac{1}{4}$--see our general catalogue.

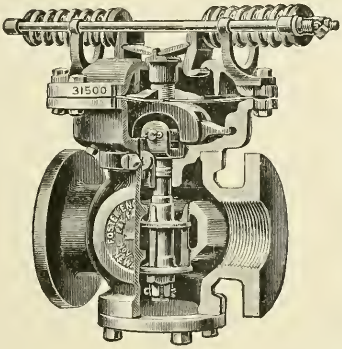
FOSTER ENGINEERING CO.

NEWARK, N. J.

MANUFACTURING ENGINEERS OF AUTOMATIC VALVE SPECIALTIES

BRANCH OFFICES: CHICAGO PHILADELPHIA BOSTON PITTSBURGH

PRESSURE REGULATOR—CLASS "W"



For Maintaining a Constant Uniform Delivery Pressure from a Higher Initial Regardless of Variations in the Boiler Pressure or Source of Supply. For Service on Steam, Water, Gas and Air.

Its "compensating spring and toggle lever arrangement" makes it phenomenally sensitive, accurate and reliable. Has no weights, levers, or close-fitting piston or parts to cause friction. Very simple in construction and adjustment. Made in sizes ½-inch to 1-inch of composition; larger sizes, iron body, composition mounted. Sizes 2½-inch and up are fitted with *renewable seats*, forged steel stem and levers—insuring **durability** and **minimum repairs.** Thousands are in use today in all civilized countries and is the "standard" of many large power and manufacturing plants.

LEADING FEATURES:

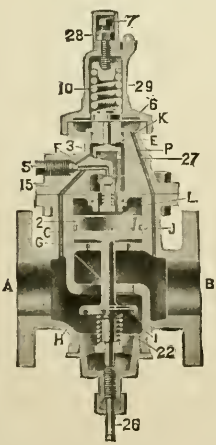
1. Full compensating spring movement, exerting an unvarying pressure on the diaphragm.
2. Renewable seat rings.
3. Drop forge stem, levers, toggle levers (case hardened) insuring *durability*.
4. Great simplicity of construction and operation.
5. Full steam way through the valve.
6. Small movement of diaphragm—insuring long life.
7. No friction of parts—note illustration.
8. No small ports to clog.
9. No dash pot.
10. Noiseless—no chatter.
11. Absolutely automatic after adjustment as to pressure.
12. Every regulator carefully tested at pressure ordered before leaving factory.

ORDERS FOR PRESSURE REGULATING VALVES SHOULD SPECIFY:

1. Initial or boiler pressure.
2. Maximum and minimum delivery pressure.
3. Connections—screwed or flanged ends, giving diameter.
4. Sizes of both pipes leading to and from regulator.
5. Device or system to which it is to be applied.
6. For high or low pressure service.
7. Size of valve preferred and if we will be permitted to send a smaller size if we deem a smaller valve will give better results. By following our suggestions we often save considerable money for our users.
8. Any additional information towards an intelligent understanding of your requirements will insure your receiving a valve best suited to meet conditions.

FOSTER CLASS "G" PRESSURE REGULATING VALVE

FOR INTERMITTENT SERVICE



A decided innovation, so extremely sensitive and withal so reliable that delivery pressure may be adjusted from zero to within a fraction of the initial pressure, and at point of adjustment the delivery will remain constant, regardless of variation in initial pressure or volume of discharge.

Will operate equally well on horizontal or vertical pipe; upright, inverted or inclined at any angle.

Although of wide range of operation, no part of this valve is of delicate construction or easily deranged.

Orders should state initial and delivery pressures, connections, service and approximate volume of discharge. (See above.)

Made in all sizes, ½-inch to 12-inch. **Sizes 2-inch and smaller of composition only.** Larger sizes, iron body, composition trimmed. Screwed and flanged connections. Also make larger sizes in composition on order only.

Prices on application.

THE CHAPMAN VALVE MFG. CO.

INDIAN ORCHARD, MASS.

STEEL PARALLEL SEAT, DOUBLE GATE VALVE FOR SUPERHEATED STEAM
STEEL BODIES AND BONNETS, MONEL METAL GATES AND SEATS

STRAIGHTWAY TYPE

Fig. 312 is a cut of the internal working parts, showing the carrier block extended to carry an opening the full size of the pipe line, so that when the valve is fully open the seats are covered and the pipe line is made continuous, the carrier extension effectually filling up the aperture around the seats.

The valve when open is the same as if it were a continuation of the pipe line, with neither contractions or apertures of any kind to deflect or break up the flow of the steam. This construction not only prevents the loss of head due to eddying, but it also protects the seats from injury.

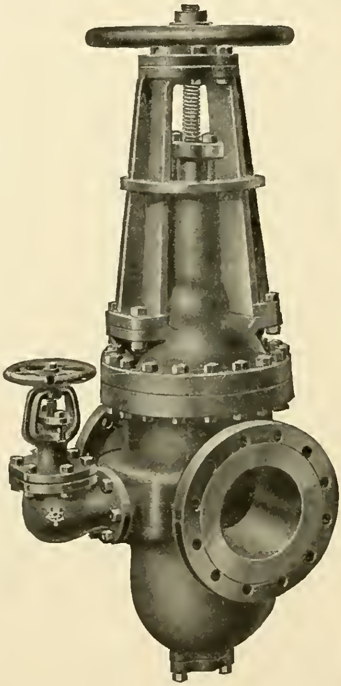


Fig 311

Diameter of Port or Size=A
Face to Face Flanges=B
Diameter of Flanges=C

A	2	2½	3	3½	4	4½
B	10¼	12½	14	14¾	18½	18½
C	6½	7½	8¼	9	10	10½
A	5	6	7	8	9	10
B	18½	19	20	20⅝	21⅞	22¾
C	11	12½	14	15	16	17½
A	12	14	16	18	20	24
B	23¾	25⅞	32⅞	33¼	35¼	35⅞
C	20	22½	25	27	29½	34

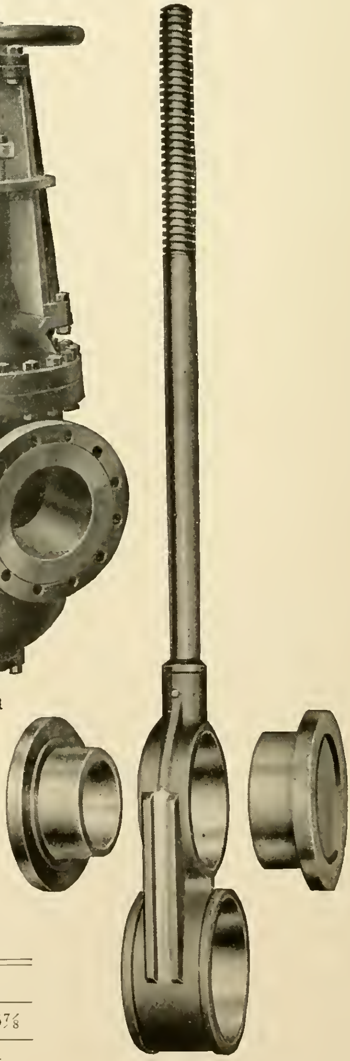


Fig 312

PAGES 64-65 CATALOGUE NO. 30

HOMESTEAD VALVE MANUF'G CO.

PITTSBURGH, PA.

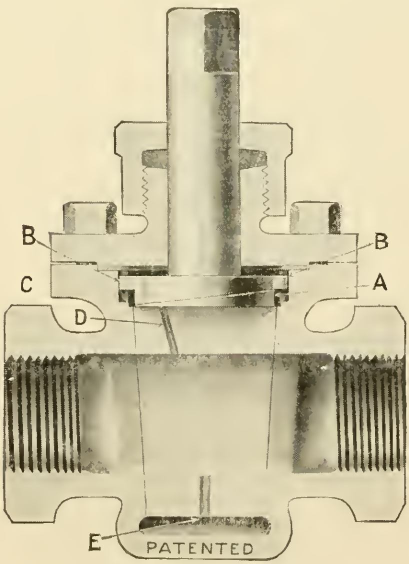
THE HOMESTEAD SELF-LOCKING STRAIGHTWAY, THREE-WAY AND FOUR-WAY HIGH PRESSURE BALANCED PLUG VALVES. THE HOMESTEAD LOCKING COCK.

THE HOMESTEAD SELF-LOCKING STRAIGHTWAY VALVE

This valve is unlike all others for the reason that when the pressure passes through it the seat is ABSOLUTELY PROTECTED FROM WEAR. The plug is balanced and held in place by the pressure when open, and when closed it is locked in the seat by our patent wedging cam, insuring freedom from friction in seat while plug is turning, which makes ours the quickest acting, simplest made, easiest operated and most durable valve known. Globe and Gate Valves, on the other hand, have their vital parts (Seats) EXPOSED to pressure and destruction every moment they are open.

CONSTRUCTION

This valve is so constructed that when it is closed it is at the same time forced firmly to its seat. This result is secured by means of the traveling cam "A" through which the stem passes. The cam is prevented from turning with the stem by means of the lugs "B" which move vertically in slots. Supposing the valve to be open, the cam will be in the lower part of the chamber in which it is placed, and the plug will be free to be easily moved. A quarter of a turn in the direction for closing it causes the cam to rise and take a bearing on the upper surface of the chamber, and the only effect of further effort to turn the stem in that direction is to force the plug more firmly to the seat. A slight motion in the other direction immediately releases the cam and the plug turns easily, being arrested at its proper open position by contact of the fingers of the cam at the other end of its travel. E. D. D. are balancing ports which allow the pressure to predominate at the top of plug, holding it gently in its seat while valve is open. Made in all sizes up to six inches, and for all pressures up to 5,000 pounds per square inch. Made in Straight Way, Three and Four-Way Patterns.
For Steam, Compressed Air and Hydraulic Service.



Homestead Straightway Valve

THE HOMESTEAD LOCKING COCK

is made with a double external locking device, which forces absolutely tight adherence of the plug to the seat at each end of the quarter turn to which it is limited, insuring easy turning and almost entire freedom from wear, giving you SIMPLICITY, RAPIDITY and DURABILITY combined.

The Homestead Locking Cock

THE KELLY & JONES CO.

GREENSBURG, PA.

Manufacturers of

BRASS AND IRON PIPE FITTINGS, BRASS AND IRON VALVES, COCKS, ETC.

FOR STEAM, GAS, WATER, AIR AND OIL

Cast Iron Fittings

CAST IRON FITTINGS

All styles, screwed or flanged for all pressures.

All K. & J. cast iron fittings are made of the best grade iron, threads cut true to standard gauge and each fitting recessed.

Malleable Fittings

"Excelsior" Valves
Brass—High Pressure

MALLEABLE FITTINGS

All styles—for all pressures. Plain, beaded or flat band.

BRASS FITTINGS

Screwed or flanged, rough or finished—standard or extra heavy.

DRAINAGE FITTINGS

Our line of special recessed fittings for wrought iron drainage systems has been in satisfactory use for years.

Jenkins Disc Brass
Valves

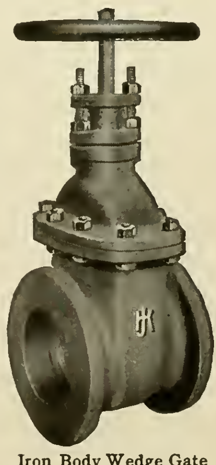
Brass Wedge Gate
Valves

BRASS VALVES

We make a brass valve for every purpose and each valve a perfect product. Only the best grades of raw material used and each valve thoroughly tested to pressure recommended.

IRON BODY VALVES

Our line of iron body valves is most complete. We make every style and for all pressures.



Iron Body Wedge Gate
Valves

JENKINS BROS.

80 White St., NEW YORK — 524 Atlantic Ave., BOSTON
133 No. Seventh St., PHILADELPHIA — 300 W. Lake St., CHICAGO

JENKINS BROS., LIMITED
103 St. Remi St., Montreal — 95 Queen Victoria St., London, E. C.
JENKINS RUBBER CO., ELIZABETH, N. J.

MANUFACTURERS OF JENKINS BROS. VALVES, PACKING, AND OTHER MECHANICAL RUBBER GOODS

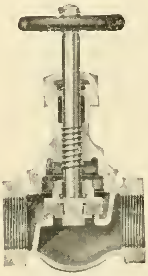


Fig. 105
Sectional view of Brass Globe Valve Standard Pattern

JENKINS BROS. BRASS VALVES

Jenkins Bros. Brass Valves, Standard Pattern, are made in globe, angle, cross, check, safety, Y and radiator patterns. They are the original renewable disc valves.

The Jenkins Discs, with which they are fitted, are of special rubber composition, readily adapting themselves to the raised seats ensuring absolutely tight closure. As there is no metal-against-metal contact of seats, there is less abrasion and wear, and the labor of regrinding is obviated. Jenkins Discs are inexpensive, give long service, and when worn out can be readily renewed without removal of valves from piping. As regularly supplied, valves are fitted with discs of hard composition for steam service. For cold water, air or gas, discs of softer composition are recommended. The valves are guaranteed for working steam pressures up to 150 pounds.

JENKINS BROS. IRON BODY VALVES

Jenkins Bros. Iron Body Valves, Standard Pattern, are made in globe, angle, cross, check, Y, safety and back pressure patterns. They are heavy and strong. The working parts are similar in construction to the standard pattern brass valves, and they are regularly fitted with Jenkins composition discs. All parts, including raised seat, are interchangeable and renewable. Guaranteed for working steam pressures up to 150 pounds.

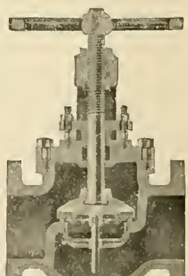


Fig. 102
Sectional view of Iron Body Globe Valve Extra Heavy Pattern

Fig. 339
Sectional view of Iron Body Swing Check Valve, Extra Heavy Pattern

JENKINS BROS. EXTRA HEAVY VALVES

Jenkins Bros. Extra Heavy Valves are designed for 250 pounds working pressure. The Globe, Angle and "Y" or Blow-off Valves are made in brass, either screwed or flanged, sizes ¼ to 3 inches, and iron body 2 to 12 inches inclusive. The valves are well designed, made of the very best steam metals, and great care is taken with the workmanship. The spindles are large and have powerful Acme standard threads.

The stuffing boxes are also large and arranged so that they can be packed under full pressure when wide open. They are fitted with renewable steam metal discs when used for steam, with Jenkins Discs for cold water service, and also have removable seat rings which can be reground or renewed when necessary.

A full line of Extra Heavy Horizontal, Angle and Swing Check Valves is also made equally heavy in design and can be recommended as being fully adapted to the service required.

As regularly made, all these Extra Heavy Valves are tested to 800 pounds hydraulic pressure. The factor of safety is so high, however, that the test pressure can be increased to double this figure if required and the valves may be safely used on hydraulic or air pressures up to 800 pounds.

JENKINS BROS.

JENKINS BROS. EXTRA HEAVY AUTOMATIC EQUALIZING STOP AND CHECK VALVES

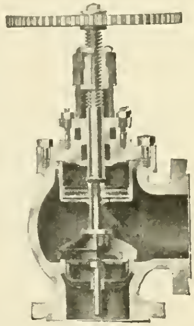


Fig. 203
Sectional View of Automatic Stop and Check Valve, Angle Pattern

are designed to shut off, automatically, the flow of steam from the header to a boiler in case a tube should burst or other internal rupture occur, thereby suddenly reducing the pressure in the boiler. They also serve to equalize the pressure in a battery of boilers and prevent one boiler from working at a lower pressure than the others. As the valves can only be opened by the pressure in the boiler it is impossible to turn steam accidentally into a boiler which is being cleaned. To prevent chattering, the valve is cushioned by an internal dashpot made of bronze which eliminates all danger of sticking through corrosion.

Each valve is carefully tested to 800 pounds hydraulic pressure and is guaranteed for working steam pressures up to 250 pounds. The stuffing-boxes can be packed when valve is wide open under full pressure.

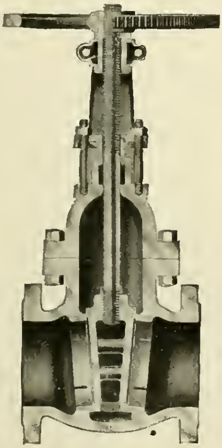


Fig. 245
Sectional View of Extra Heavy Iron Body Gate with Outside Screw and Yoke

JENKINS BROS. GATE VALVES

are a comparatively new, and distinctly high grade line. They are made in brass or iron body in three distinct patterns: Standard, for 125 pounds working steam pressure, or 175 pounds water; Medium, for 175 pounds steam or 250 pounds water; Extra Heavy, for 250 pounds steam or 400 pounds water.

They are all of the solid-wedge, double-face type. The wedge or gate is guided by ribs cast on the inside of the body, which fit in corresponding channels in the wedges, thereby preventing the wedge from dragging across the seat, preventing uneven wear on the faces, or chattering when valve is partly open.

One of the important features of these valves is the improved globe shaped body, a novel design which is used because it secures the greatest possible strength, good proportion and neat appearance.

The brass valves are regularly made in sizes ¼ to 3 inches. Larger sizes in brass can be made from iron body patterns.

Standard Iron Body Valves made in sizes 2 to 30 inches; Medium up to 18 inches; Extra Heavy up to 24 inches.

JENKINS BROS. CAST STEEL VALVES

are made in Globe, Angle, Gate and Check Patterns, which experience has shown are perfectly adapted for the severe conditions incident to high pressure superheated steam service. The steel used in these valves is made in a modern converter from selected irons and for strength, ductility and soundness the castings are fully equal to those produced commercially by any known process.

For seat-rings, discs, bushings, and spindles. Monel Metal is used, a natural alloy containing about 70 per cent nickel. The tensile strength is high, it is very hard, durable and non-corrosive and expands and contracts practically the same as cast steel. Seat-rings made of this metal do not get loose under the most severe conditions.

The valves are suitable for working steam pressures up to 350 pounds, and total temperature of 800° F.

All the genuine Jenkins Bros. Valves bear the Diamond Trade Mark, and are absolutely guaranteed to be perfect in workmanship and suitable and efficient in the service for which they are designed.

A catalogue of all the Jenkins Bros. products, giving sizes, styles and list prices mailed on request.

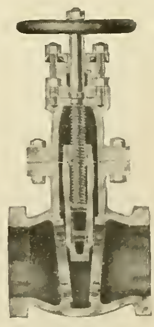


Fig. 250
Sectional View of Iron Body Gate, Inside Screw

THE LUDLOW VALVE MFG. CO.

TROY, NEW YORK

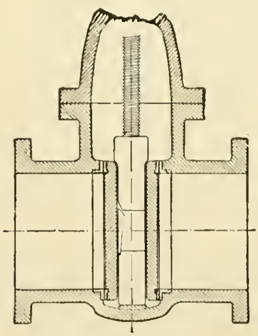
BRANCH OFFICES

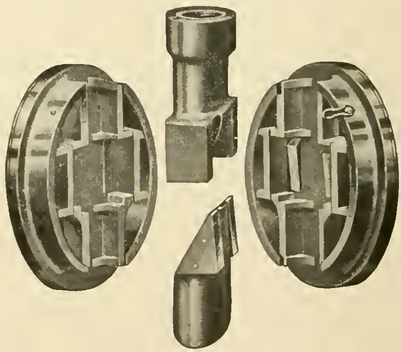
NEW YORK: 62 Gold St.
BOSTON, MASS.: Oliver Bldg.
PITTSBURGH, PA.: First Natl. Bank Bldg.
CHICAGO, ILL.: 633-635 The Rookery
PHILADELPHIA, PA.: Harrison Bldg.
KANSAS CITY, MO.: Victor Bldg.

HIGH GRADE VALVES FOR EVERY PURPOSE; VALVES FOR STEAM, WATER, OIL, GAS AND AMMONIA, OF ANY SIZE AND FOR ALL PRESSURES; AUTOMATIC AIR VALVES AND FLOAT VALVES; RELIEF VALVES; SLUICE GATES; CHECK AND FOOT VALVES; COMBINATION AIR VALVE WITH CONTROLLING GATE; HYDRANTS.

THE LUDLOW DOUBLE GATE VALVE

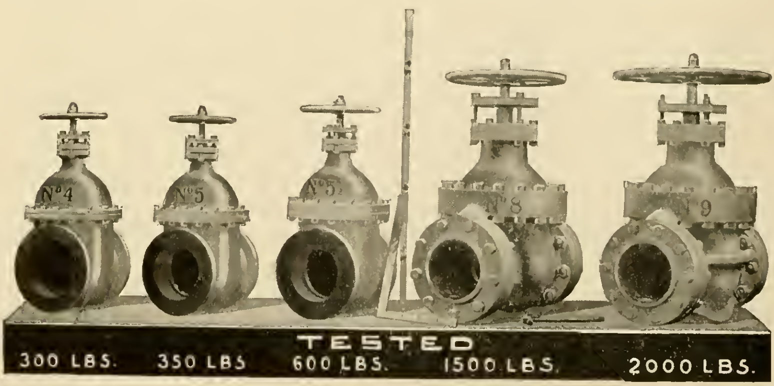
The illustrations below show section of valve and detailed view of the Gates and Wedges. The Gates cannot lock or wedge in closing until directly opposite the ports. Gates are released from seats before starting to rise, avoiding wear on seats, and grinding or dragging of faces of gates on seats is impossible. Stem cannot bind or wedge. The gates cannot cant to either side and cause stripping of threads on stem.



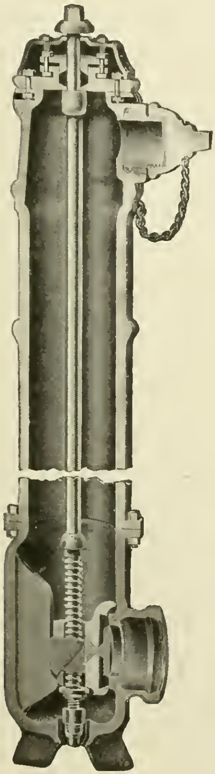


LUDLOW DOUBLE GATE VALVES FOR ALL PRESSURES

These Valves all have a 10″ opening



THE LUDLOW VALVE MFG. CO.



FIRE HYDRANTS

Genuine Ludlow Slide Gate, Frost Proof, Fire Hydrant. Rubber-faced Gate. Bronze Mounted.

(a) Simple in construction.

(b) Drip valve in extreme bottom of hydrant, draining hydrant barrel completely and permitting no water to remain in same.

(c) All working parts can be removed without disturbing hydrant barrel or doing any digging.

(d) Gate is released from seat before starting to rise, avoiding wear on gate rubber.

(e) Gate when shut remains tight when top of hydrant is removed.

(f) No flooding of street in case standpipe or barrel is broken.

(g) In opening hydrant, first turn of the stem closes the drip valve, after which the bronze wedge nut in back of gate is loosened, relieving gate from its seat.

Final turn of the stem after gate is closed and wedged opens the drip valve.

(h) Frost case unnecessary.

(i) Large waterway.

From Page 110 Ludlow Catalogue, 1910

Size of Hydrant or Diameter Valve Opening	2″	3″	4″	4½″	5″	6″	8″
Inside diam. of Stand Pipe	3″	4⅝″	5¾″	6¼″	7″	8″	10″
Size Bottom Connection	2″	3″ or 4″	4″ or 6″	6″	6″ or 8″	6″ or 8″	8″ or 10″
Number and Size Nozzles	1-2″	1-2½″	2-2½″	3-2½″	3-2½″	4-2½″	6-2½″

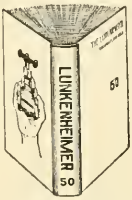
Steamer nozzle can be added on sizes 4″ and up, or can be substituted for 2½″ nozzles. Inside independent cut-off gate can be furnished on 2½″ nozzles if wanted.

THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

BRASS, IRON, SEMI AND CAST STEEL VALVES, WHISTLES, COCKS, GAUGES, INJECTORS, LUBRICATORS, OIL PUMPS, OIL AND GREASE CUPS, MOTOR ACCESSORIES, ETC.

LUNKENHEIMER CATALOGUE



We illustrate on this and the three following pages only a few of our leading specialties, the whole being considerably condensed, owing to the lack of space. For a complete description, with sectional illustrations of the following, together with a large number of other engineering appliances, reference must be had to our Catalogue, a copy of which can be had free of charge.

This book consists of 670 pages, is handsomely bound and illustrated, and shows, describes and lists the entire line of Lunkenheimer products, which is not only the largest line of high grade engineering specialties in the world, but the variety of these appliances is by far the greatest.

The Lunkenheimer Catalogue also contains tables and information of great value and of daily use to engineers in general,—in fact, it is a book that no engineer can afford to be without. Write for a copy.

LUNKENHEIMER REGRINDING VALVES

BRASS

Made in Globe, Angle and Cross Patterns; Screw or Flange Ends; Medium weight, for working pressures up to 200 pounds, Extra Heavy for 300 pounds; sizes ranging from 1/8 to 4 inches inclusive.

These valves can be reground quite a number of times, without removing them from their connecting pipes, making them as tight as when new. The discs and all other parts are renewable; the stuffing-boxes can be repacked under pressure when the valves are wide open; the areas through the bodies are in excess of the nominal inside diameter of the connecting pipes, and the union connection between the body and hub provides a non-corrosive, re-inforcing joint.

LEADING DIMENSIONS

Size of Valve	inches	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
Face to Face Screw End Globe Valve	Medium, "	1 19/32	2 1/32	2 1/8	2 7/16	2 15/16	3 11/32	3 7/8	4 5/16	5 1/4	6 7/16	7 3/16	8	9
	Ex. Hy., "	...	2 1/4	2 7/16	2 23/32	3 3/8	3 3/4	4 9/32	4 7/8	5 7/8	7 1/16	7 7/8	9	10 1/16
Center to Face Screw End Angle or Cross Valves	Medium, "	25/32	1	1	1 3/16	1 3/8	1 5/8	1 7/8	2 1/8	2 9/16	3 5/16	3 3/4	3 15/16	4 5/8
	Ex. Hy., "	...	1	1 3/16	1 9/32	1 9/16	1 13/16	2 3/32	2 3/8	2 11/16	3 17/32	4	4 1/2	5 1/32
Face to Face Flange End Globe valve	Medium, "	...	...	2 7/8	3 5/8	4 3/16	4 5/8	4 7/8	5 7/8	6 7/8	7 13/16	8 7/16	9 1/16	10 1/16
	Ex. Hy., "	...	...	3 1/4	3 7/8	4 1/2	4 3/4	5 1/4	6 3/8	7 3/8	8 9/16	9 3/8	9 13/16	10 3/4
Center to Face Flange End Angle or Cross Valve	Medium, "	...	...	1 21/32	1 31/32	2 1/4	2 17/32	2 13/16	3 3/32	3 5/8	4 3/16	4 15/32	5	5 9/32
	Ex. Hy., "	...	...	1 23/32	2 1/32	2 6/16	2 5/8	2 29/32	3 3/16	3 3/4	4 5/16	4 11/16	5 6/16	5 13/16
Center of Port to Top of Stem, when open	Medium, "	2 15/16	4	4	4 7/16	4 7/8	5 3/4	6 5/16	6 15/16	8 5/16	9 3/16	9 13/16	11 3/4	12 15/16
	Ex. Hy., "	...	4 3/16	4 3/16	4 11/16	5 7/16	6 3/8	6 15/16	7 3/4	9 1/8	10 1/4	11 1/16	12 3/4	14

THE LUNKENHEIMER COMPANY

LUNKENHEIMER BRASS "RENEWO" VALVES

Globe, Angle and Cross Patterns; Screw of Flange Ends; Medium weight, for working pressures up to 200 pounds, Extra Heavy for 300 pounds; sizes from 1/4 to 3 inches inclusive.

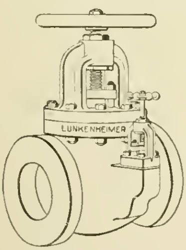
All parts are renewable, including the seat and disc, and the seating faces are also regrindable. Both seat and disc are made of a most durable nickel alloy, and their unique construction reduces the wear on the seating faces, caused by the great velocity of the steam flowing through the valve, makes them self-cleansing and eliminates water-hammer.

Areas through the bodies are larger than those of the connecting pipes; stuffing-boxes can be packed under pressure when the valves are wide open, and the valves are provided with a non-corrosive union connection between the body and hub.

LEADING DIMENSIONS

Size of valve	inches	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
Face to Face Screw End Globe Valves	Medium, inches	2 3/32	2 9/32	2 5/8	3 7/32	3 3/4	4 1/4	4 3/4	5 3/4	6 13/16	7 3/4
	Ex Hy., inches	2 5/16	2 15/32	2 7/8	3 17/32	4 1/8	4 23/32	5 1/4	6 3/8	7 3/8	8 3/8
Center of Port to Face of Screw End Angle Valves	Medium, inches	1	1 1/16	1 1/4	1 15/32	1 11/16	1 15/16	2 3/16	2 5/8	3 5/16	3 13/15
	Ex Hy., inches	1 3/32	1 5/32	1 3/8	1 5/8	1 29/32	2 7/32	2 7/16	3	3 19/32	4 1/8
Center of Port to Face of Screw End Cross Valves	Medium, inches	1	1 1/16	1 1/4	1 15/32	1 11/16	1 15/16	2 3/16	2 5/8	3 9/16	4 1/16
	Ex Hy., inches	1 3/32	1 5/32	1 3/8	1 5/8	1 29/32	2 7/32	2 7/16	3 3/8	3 13/16	4 5/16
Face to Face Flange End Globe Valves	Medium, inches	...	3	3 7/16	4	4 9/16	5 1/16	6 1/8	7 1/4	8	9
	Ex Hy., inches	...	3 1/4	3 11/16	4 3/8	5 1/16	5 9/16	6 13/16	8	9	10
Center of Port to Face of Flange End Angle or Cross Valves	Medium, inches	...	1 21/32	1 31/32	2 1/4	2 17/32	2 11/16	3 3/32	3 5/8	4 3/16	4 1/2
	Ex Hy., inches	...	1 23/32	2 1/32	2 5/16	2 5/8	2 29/32	3 13/32	4	4 1/2	5
Center of Port to Top of Stem, when open	Medium, inches	3 7/8	3 7/8	4 5/16	5 13/16	6 5/16	7	7 5/8	8 11/16	9 7/8	10 15/16
	Ex. Hy., inches	4 6/16	4 5/16	4 3/4	5 29/32	6 3/4	7 5/8	8 11/32	9 17/32	11 1/16	12 1/2

LUNKENHEIMER IRON BODY BRASS MOUNTED; "PUDDLED" SEMI-STEEL AND CAST STEEL GLOBE, ANGLE AND CROSS VALVES



Iron Body Brass Mounted—Medium Pattern, for working pressures up to 125 pounds, Heavy for 175 pounds and Extra Heavy for 250 pounds; Screw or Flange Ends. Extra Heavy Pattern can be had with or without interior or exterior by-pass. Medium and Heavy Patterns made in sizes from 2 to 12 inches inclusive; Extra Heavy without by-pass, from 2 to 10 inches, and with by-pass, from 3 1/2 to 12 inches inclusive.

All parts subjected to wear are renewable; the seating faces of both the main and by-pass valves are regrindable, and the stuffing-boxes can be packed under pressure when valves are wide open.

For superheated steam, these valves can be had made of "Puddled" Semi-steel, a material having a tensile strength of 35,000 pounds per square inch; and for extreme conditions of pressure, superheat and strain, of cast Steel, the tensile strength of which is about 80,000 pounds per square inch.

LEADING DIMENSIONS OF IRON BODY AND "PUDDLED" SEMI-STEEL VALVES

Size of Valve	inches	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8	10	12
Face to Face Screw End Globe Valves	Med & Hy., in.	6 1/16	7 3/16	8 1/16	9	10	11 1/8	12	13 1/2	15 3/4	18	23 1/4	27
	Ex Hy., inches	8 3/16	10 5/8	11 3/4	12 3/4	13	14	14 7/8	16 1/2	18 1/4	20	23 1/4	27 3/4
Center of Port to Face of Screw End Angle or Cross Valves	Med & Hy., in.	3 1/16	3 19/32	4 1/16	4 1/2	5	5 9/16	6	6 3/4	7 7/8	8 5/8	10	11 7/8
	Ex Hy., inches	4 3/32	5 3/8	5 7/8	6 3/8	6 1/2	7	7 1/2	8 1/4	9 1/8	10	11 5/8	13 7/8
Face to Face of Flange End Globe Valves	Medium, inches	7 1/2	8 1/2	9 1/4	10 1/4	11	12	12 3/4	14 1/8	16 1/8	19 1/4	24 1/4	27 1/2
	Heavy, inches	8	9 1/8	10	11	11 5/8	12 3/4	13 5/8	15	17	20 1/4	24 1/4	27 1/2
	Ex. Hy., inches	9 3/4	11 1/2	12 1/2	13 1/2	14	15	15 3/4	17 1/2	19 1/4	21 3/4	25 3/8	28 5/8
Center to Face of Flange End Angle or Cross Valves	Medium, inches	3 3/4	4 1/4	4 5/8	5 1/8	5 1/2	6	6 3/8	7 1/16	8 1/16	8 3/4	10 1/8	12
	Heavy, inches	4 3/8	5	5 5/8	6 1/16	6 5/8	6 15/16	7 1/4	8 1/16	9	9 5/8	11 1/4	12 3/4
	Ex Hy., inches	4 7/8	5 3/4	6 1/4	6 3/4	7	7 1/2	7 7/8	8 3/4	9 5/8	10 1/2	12 1/4	14
Center of Port to Top of Stem, when open	Medium, inches	9 1/4	10 5/8	11 1/2	13 1/4	14 5/8	15 5/8	17	18 5/8	20 1/4	22 1/2	26 7/8	30 1/2
	Heavy, inches	9 1/4	10 5/8	11 1/2	13 1/4	14 5/8	15 5/8	17	18 5/8	20 1/4	22 1/2	26 7/8	30 1/2
	Ex Hy., inches	13 1/4	14 3/4	16 3/8	17 3/4	19 1/2	20 1/2	22	24	27 1/4	29 7/8	35 7/8	40 1/4
Center of Valve to End of By-pass, Extra Heavy Pattern	inches	...	...	...	7 1/8	7 3/4	8	9 3/4	10 7/8	11 7/8	13 1/8	16	17 3/4

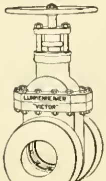
(See also next page)

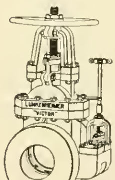
(Continued from preceding pages)

THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

LUNKENHEIMER IRON BODY BRASS MOUNTED; "PUDDLED" SEMI-STEEL AND CAST STEEL "VICTOR" GATE VALVES





Made with either stationary stem inside screw, or rising stem and yoke; with or without by-pass, screw or flange ends.

Iron Body Brass Mounted—Standard Pattern, sizes 2 to 24 inches. From 2 to 8 inches inclusive for working pressures below 125 pounds; above 8 inches for pressures up to 100 pounds. Medium Pattern for working pressures up to 125 pounds; without by-pass in sizes 2 to 24 inches; with by-pass, 5 to 24 inches. Heavy Pattern for 175 pounds working pressure; without by-pass, sizes 2 to 24 inches; with by-pass, 5 to 24 inches. Extra Heavy Pattern for pressures up to 250 pounds; without by-pass, sizes 1½ to 16 inches; with by-pass, 5 to 16 inches.

All parts subjected to wear are renewable, and this includes the seats and discs. The valves are double-seated and will therefore take pressure from either end; both the main and by-pass valves can be packed under pressure when the valves are wide open, and the by-pass seating faces can be reground.

For superheated steam, the "Victor" Gate Valves are made of "Puddled" Semi-steel, and for extreme conditions of pressure, superheat and strain, they are made of Cast Steel.

LEADING DIMENSIONS OF IRON BODY BRASS MOUNTED AND "PUDDLED" SEMI-STEEL VALVES

Size of Valve.................inches		1½	2	2½	3	3½	4	4½	5	6	7	8
Face to Face Screw Ends..	Standard	...	4	4½	4⅞	5⅜	6⅛	6½	6⅞	7⅝	8¼	9
	Med & Hy	...	4½	5 3/16	5 7/16	5 11/16	6	6 3/16	7 5/16	7⅞	9¾	10⅜
	Ex Heavy	4⅞	5 7/16	6 3/16	6 11/16	7 1/16	7 13/16	8 3/16	8¾	9⅝	11⅛	12⅛
Face to Face Flange Ends	Standard	...	5	5½	5⅞	6¼	7⅜	7½	7⅞	8⅝	9⅛	9¾
	Medium	...	5¼	5 11/16	6⅛	6½	7⅛	7½	8 15/16	9½	10⅞	11¾
	Heavy	...	6⅝	7⅝	8½	8⅝	9	9⅝	10¼	10⅞	12⅛	13⅛
	Ex. Heavy	5¾	6⅝	7⅝	8½	9	9⅝	10⅜	12¾	13½	15	16½
Center of Port to Top of Stem, Stationary Stem Pattern..............	Standard	...	9¾	11⅝	13⅛	14⅛	15⅝	16⅞	18½	20⅞	22¾	25¾
	Med & Hy	...	10	12¼	13¾	14¾	16¼	17¼	19	21	22¾	26
	Ex Heavy	10¼	12	13¾	14¾	16½	18	19¼	20¾	23¾	25½	28
Center of Port to Top of Stem, when open, Rising Stem & Yoke Pattern..	Standard	...	12⅞	15	16⅝	19⅜	21¼	23¼	25¾	30	33¾	38¼
	Med & Hy	...	13	15½	17¼	20½	22¾	24½	26¾	31	34¾	39
	Ex Heavy	12¾	14½	17	18¾	21	23¼	25	27½	32¼	35½	39½
Center of Body to End of By-pass..............	Med & Hy	...	...	...	...	...	...	...	6½	7¼	8	9
	Ex Heavy	...	...	...	...	...	...	...	9¼	10½	11	12¼

Size of Valve.......................inches		9	10	12	14	15	16	18	20	22	24
Face to Face Screw Ends......	Standard	...	10⅛	11⅜	...	...	...	...	...	...	...
	Med & Hy	11¼	13	14¼	...	...	...	...	...	...	...
	Ex Heavy	...	14¾	16	...	...	...	...	...	...	...
Face to Face Flange Ends.....	Standard	...	10¾	11¾	13	13½	14	16	17	18	19
	Medium	12½	14¼	15	16½	16¾	18½	22	24	25	26
	Heavy	14	15⅝	16½	18	18⅜	20⅛	23⅝	25⅝	26⅝	27¾
	Ex Heavy	...	19	19¾	21¼	22½	24	...	...	...	...
Center of Port to Top of Stem, Stationary Stem Pattern.....	Standard	...	30	34⅜	37⅞	39½	42	46¼	50⅞	54½	59
	Med & Hy	27½	30	34¾	38	39½	42	46½	51½	55	59½
	Ex Heavy	...	32½	37	40½	42½	45½	...	...	...	...
Center of Port to Top of Stem, when open, Rising Stem & Yoke Pattern..............	Standard	...	46	54	61½	65¼	69½	75⅝	83 7/16	91	98¼
	Med & Hy	43¾	47	54½	62½	66½	71	77	85½	92½	101
	Ex Heavy	...	47½	55	62½	66½	70½	...	...	...	...
Center of Body to End of By-pass......................	Med & Hy	9¾	10¾	11¾	13¾	14½	15	19½	21½	22½	24
	Ex Heavy	...	14½	15¾	17	18	19¼	...	...	...	...

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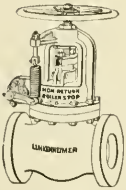
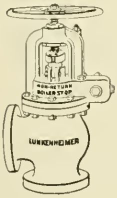
THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO





LUNKENHEIMER NON-RETURN SAFETY BOILER STOP VALVES

Iron Body Brass Mounted; "Puddled" Semi-steel and Cast Steel

Made in sizes from 4 to 10 inches inclusive, screw or flange ends, and in five different combinations of material to suit the requirements of various conditions of superheat and high pressure, and to meet the specifications of engineers who may differ as to what is best suited to the purpose.

Valves will immediately close in case of a sudden decrease in pressure on the boiler side of the disc, caused by the blowing out of a tube in the boiler or any rupture of the headers, shell, etc. Chattering or vibration of the disc is overcome by an ingenious outside spring arrangement. Valves cannot be opened by hand, but can be positively closed.

Of extra heavy construction, well made in every detail, and guaranteed in every particular. All parts subjected to wear are renewable.

LEADING DIMENSIONS

Size of Valve............inches	4	4½	5	6	7	8	10
Face to Face, Screw End Globe Valve........inches	13	14	14⅞	16½	18¼	20	23¼
Center to Face, Screw End Angle Valve......inches	6½	7	7½	8¼	9⅛	10	11⅝
Face to Face, Flange End Globe Valve.......inches	14	15	15¾	17½	19¼	21¾	25⅜
Center to Face, Flange End Angle Valve.....inches	7	7½	7⅞	8¾	9⅝	10½	12¼
Center of Body to Top of Stem, open: Globe Valve..inches	21¼	23	25	27	31¾	33½	40¾
Center of Body to Top of Stem, open: Angle Valve..inches	21	22¾	24¾	27	31	33	39½
Center of Body to Extreme End of Yoke......inches	9	9½	9⅞	11	12⅜	14	16½

LUNKENHEIMER "PUDDLED" SEMI-STEEL VALVES

Particularly adapted for high pressures and superheated steam.

The "Puddled" Semi-steel as used in Lunkenheimer valves is an extremely high-grade iron and steel alloy of very close grain and great strength, the tensile strength per square inch being about 35,000 pounds.

All parts subjected to wear are renewable, making the valves practically indestructible.

The line includes Globe, Angle, Cross, Gate, Check and Non-return Safety Boiler Stop Valves, guaranteed for working pressures up to 250 pounds per square inch, and to suit various conditions of superheat and meet the specifications of engineers who differ as to the material used for the trimmings, "Lunkenheimer "Puddled" Semi-steel Valves are made in two combinations.

LUNKENHEIMER CAST STEEL VALVES

For extreme conditions of pressure, superheat and strain, Lunkenheimer Cast Steel Valves are unexcelled.

They are the only cast steel valves made to meet standard specifications and are the only steel valves containing less than .05 per cent of either phosphorus or sulphur.

The tensile strength of Lunkenheimer Cast Steel is about 80,000 pounds per square inch, with a safe elastic limit and excellent elongation.

To suit the requirements of various conditions of superheat and high pressure, and also to meet the specifications of engineers who may differ as to what is best suited to the purpose, Lunkenheimer Cast Steel Valves are made in two combinations as regards the material used for the trimmings.

The line includes Globe, Angle, Gate, Non-return Safety Boiler Stop Valves, etc.

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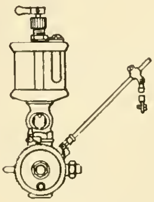
THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

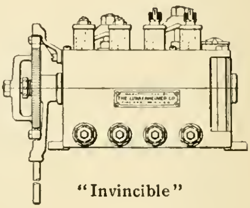
LUNKENHEIMER MECHANICAL OIL PUMPS



"Marvel"

More efficient and economical than hydrostatically operated lubricators.

The Single-Feed "Marvel" is made in 1-pint, 1-quart and ½-gallon capacities; Double-Feed "Marvel" in 1-quart and ½-gallon capacities, and the "Invincible" in one to four feeds with capacities ranging from one-quart to one-gallon.



"Invincible"

LUNKENHEIMER OIL AND GREASE CUPS

The Lunkenheimer line of oil and grease cups is undoubtedly the largest and most complete on the market, and among the great variety of designs can readily be found a cup particularly adapted to any desired requirement.

They are free from complicated parts, are well made of the best materials, very neat in appearance and are absolutely reliable. Lunkenheimer Oil and Grease Cups are exceptionally durable and very strong, particularly in the shank, the part subjected to the greatest strain. Jarring of the machinery to which they are attached will not shake them to pieces, nor will the regulation of the feed be affected.

On this and the following pages are illustrated and briefly described only a few designs of Lunkenheimer Oil and Grease Cups. For a complete description with sectional illustrations of the large and complete line, send for a copy of our general catalogue.

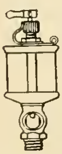
LUNKENHEIMER "PIONEER" OIL CUPS

"Pioneer"

Provided with glass body and made in eleven (11) sizes, capacities from ¼ to 34 ounces. Adapted for all engine and machinery bearings.

Feed of oil can be regulated to a very fine degree, and means are provided for preventing unsetting of feed. Made of the highest grade of cast bronze.

LUNKENHEIMER "SENTINEL" OIL CUPS



"Sentinel"

Have glass bodies and are provided with large sight-feeds. Made in nine (9) sizes, from ⅝ to 34 ounce capacities.

Regulation of the feed can be finely adjusted. By means of the snap lever at the top of the cup, the feed can be stopped or started without unsetting the feed regulation, so that after the cup is set for a desired feed, the regulation need never be tampered with.

The sight-feeds are exceptionally large and the dropping oil can clearly be seen from quite a distance.

LUNKENHEIMER BRASS BODY OIL CUPS

With Screw Cap

Made with Hinged Lid in seven (7) sizes, capacities ranging from 3/10 to 3 5/10 ounces, or with Spring Lid or Screw Cap in eleven (11) sizes, capacities from 1/10 to 6 5/10 ounces.

Material used is of the highest grade bronze composition. The cups are exceptionally strong and guaranteed to give perfect satisfaction.

With Hinge Lid

(Continued from preceding pages).

THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

LUNKENHEIMER "IDEAL" AUTOMATIC GREASE CUP

"Ideal"

This cup is heavy in design, elegantly finished and made of the highest grade of bronze composition. It is of the automatic compression type and can be depended upon to feed the quantity of grease for which it is set. The regulation of the feed is accomplished by means of a screw in the shank.

It is intended for use on engine crank pins, journals, etc. Made in seven (7) sizes, for capacities from 1/3 to 18 ounces.

LUNKENHEIMER "LION" AUTOMATIC GREASE CUP

"Lion"

Intended for all kinds of machinery bearings. Automatically feeds any quantity of grease desired. The grease reservoir is removable, to facilitate the filling of the cup.

Made of bronze in seven sizes, capacities ranging from 1/3 to 18 ounces.

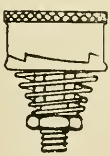
LUNKENHEIMER SCREW-FEED "MARINE" GREASE CUP

"Marine"

Intended for such purposes where grease is fed to bearings from a distance. Of heavy design and absolutely reliable.

Made of bronze in seven sizes, capacities ranging from 1/3 to 18 ounces.

LUNKENHEIMER "LOCK" GREASE CUP

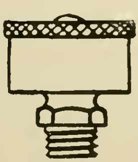


"Lock"

A screw compression cup with spring ratchet attachment, to prevent the cap from jarring off. Particularly adapted to all machinery subjected to excessive vibration. Made of a high grade bronze composition and exceptionally strong and durable.

Can be had in five sizes, for capacities ranging from 1/8 to 2 ounces.

LUNKENHEIMER "TIGER" PLAIN BRASS GREASE CUP



"Tiger"

This cup is of the plain screw compression type, equipped with a spring lock, to prevent the cap from jarring off. They are furnished in three styles,—Finished Brass, Nickel Plated or Rough.

Made in seven styles, for capacities from 1/8 to 5 ounces. They are guaranteed to be absolutely reliable and made of the highest grade of bronze composition.

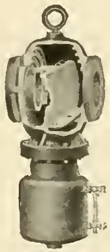
PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

PITTSBURGH, PA.

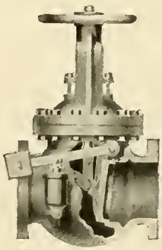
ENGINEERS, MANUFACTURERS AND ERECTORS

Designers and Builders of Valves, Fittings and Appliances of Every Description for Steam, Gas, Water, Air and Hydraulic Piping.

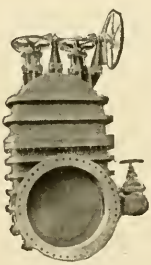
Designs and Estimates for special valves and equipment furnished upon receipt of specifications.



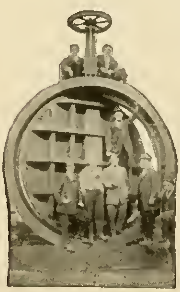
Atwood Horizontal Separator



Outside Dashpot Non Return Valve



48″ Double Spindle Gate Valve



120″ Butterfly Valve

Hand Operated Gate Valves.
Electrically Operated Gate Valves.
Cylinder Operated Gate Valves.
Quick Opening Gate Valves.
Globe, Angle and Cross Valves.
Check Valves.
Butterfly Valves.
Critchlow Operating Valves.
Tanner Operating Valves.
Aiken Operating Valves.
Relief Valves.
Back Pressure Valves.
Non Return Valves.
Throttle Valves.
Transfer Valves.
Register Valves.
Float Valves.
Foot Valves with Strainers.
Blow Off Valves.
Plug Valves.
Hydraulic Cocks.
Tuyere Cocks.
Hydraulic Spring Cushions.
Gas Line Materials.
Pressure Regulating Stations.
Cast Iron Pipe.
Pipe Fittings and Flanges.
Pipe Bends.
Expansion Joints.
Exhaust Heads.
Steam Separators.
Drip Pockets.
Strainers.

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

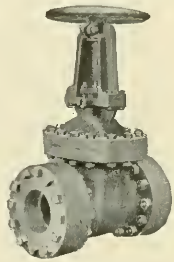
PITTSBURGH, PA.

GATE VALVES

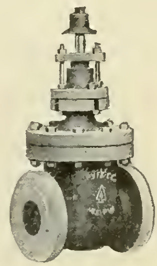
SPECIFICATIONS FOR MATERIAL	Grey Iron—22,000 lb. per sq. in. tensile strength. Semi Steel—33,000 lb. per sq. in. tensile strength.
PARALLEL SEAT 50 lb. WORKING PRESSURE 100 lb. TEST PRESSURE	Sizes 14″ to 72″ cast iron. Low pressure. For water, gas, air or exhaust steam. Extremely close face to face, invaluable in complicated piping connections.
PARALLEL SEAT 125 lb. WORKING PRESSURE 300 lb. TEST PRESSURE	Sizes 2″ to 48″ cast iron. Standard pressure. For water, air, steam or gas. Fully bronze mounted. Especially adapted to water distribution.
PARALLEL SEAT 200 lb. WORKING PRESSURE 400 lb. TEST PRESSURE	Sizes $1\frac{1}{2}$″ to 16″ cast iron. Largely used for natural gas under the lower pressures. Furnished either all iron or iron body bronze mounted.
PARALLEL SEAT 400 lb. WORKING PRESSURE 800 lb. TEST PRESSURE	Sizes 3″ to 20″ semi steel. In extensive use for the transmission of natural gas. Furnished either with or without bronze mountings.
PARALLEL SEAT 500 lb. WORKING PRESSURE 1500 lb. TEST PRESSURE	Sizes 2″ to 12″. For water or oil at pressure noted. Semi steel with solid bronze mountings.
PARALLEL SEAT 1000 lb. WORKING PRESSURE 1500 lb. TEST PRESSURE	Sizes 2″ to 12″ semi steel. High pressure gas valve used chiefly at the gas wells and on feeders in the gas fields.
PARALLEL SEAT 1500 lb. WORKING PRESSURE 2000 lb. TEST PRESSURE	Sizes 2″ to 10″ semi steel. For hydraulic service and extreme natural gas rock pressures.
TAPER SEAT 175 lb. WORKING PRESSURE 500 lb. TEST PRESSURE	Sizes 2″ to 16″ semi steel. A valve for medium steam pressures from 125 lb. to 175 lb. where a less expensive valve than the 250 lb. type is desired.
TAPER SEAT 250 lb. WORKING PRESSURE 800 lb. TEST PRESSURE	Sizes $1\frac{1}{2}$″ to 28″. Made of semi steel with solid bronze mountings for ordinary steam pressures or of cast steel with monel mountings for superheat.
TAPER SEAT 1000 lb. WORKING PRESSURE 2000 lb. TEST PRESSURE	Sizes 2″ to 10″. The strongest valve possible to make in its weight, all surfaces being cylindrical or spherical segments.
GATE VALVES FOR ANY PRESSURE	Designs and quotations furnished for valves for special conditions or higher pressures. Materials used are those best adapted to service.

(See also next page)

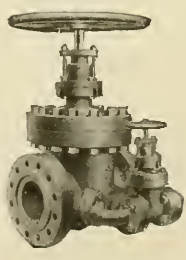
50 lb. Parallel Seat Gate Valve. Close Pattern



8″ 500 lb. Gate Valve



4″ 1000 lb. Gas Line Gate Valve

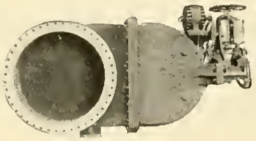


8″ 1000 lb. Hydraulic Gate Valve

(Continued from preceding pages)

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO

PITTSBURGH, PA.

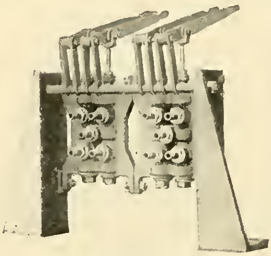


48″ Motor Operated Gate Valve

30″ Gate Valve Operated by Air Cylinder

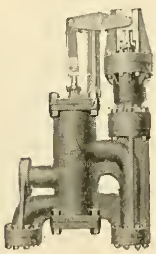
Any of the foregoing gate valves may be equipped with operating cylinders for any service or pressure, or motors for either direct or alternating current.

The following types of operating valves are extensively used for the control of motion of hydraulic cylinders, either single or double acting.



Group of Two Critchlow Nests

The **CRITCHLOW VALVE** is the simplest form of hydraulic three or four way piston valve and has no superior for working pressures up to 500 pounds. It is durable and easy to repack. The CRITCHLOW NEST furnishes a means of grouping these valves which yields a great saving in pipe, fittings, manifolds and space, where a number of cylinders are to be operated from one pulpit.



Tanner Valve with Actuating Cylinder

The **TANNER VALVE** is more satisfactory than the Critchlow on high pressures. It is of the cup-packed piston type, so designed that the fluid forces the packing away from the ports instead of into them, prolonging the life of the packing and making operation easy. The arrangement of supply and waste ports facilitates attaching to manifolds. Larger sizes can be furnished with actuating cylinder permitting remote control by means of a pilot valve.

The **AIKEN VALVE** has given complete satisfaction to a large number of users for many years. The designs and patterns for this valve have been purchased from the inventor, Henry Aiken, M.E., and valves can be made to meet any requirements.

Special facilities for casting and machining large pipe and fittings as well as all classes of work such as furnace castings, general castings, etc.

60″ x 42″ x 42″ x 42″ Special Cross with 30″ Side Outlet

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

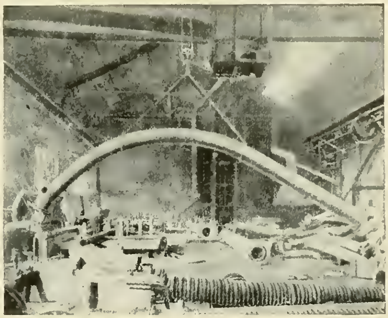
PITTSBURGH, PA.

PIPING SYSTEMS

For all Pressures and Purposes,
Designed, Manufactured
and Installed

Pipe Bending Pipe Cutting
Pipe Fitting

Estimates furnished on receipt
of specifications

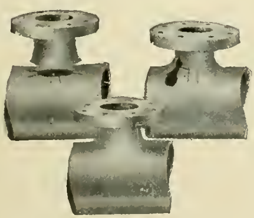


20″ Expansion Bend—Radius 16 Ft.
This bend contains 38 ft. of pipe and was made of two lengths joined in the arc by the Atwood Line Weld

The Atwood Line Weld
Patented

THE ATWOOD LINE WELD

This method of joining the abutting ends of wrought pipe allows the fabrication of pipes into lengths as long as can be handled for shipment with consequent reduction by about 50 per cent of the number of flanged joints in the line.



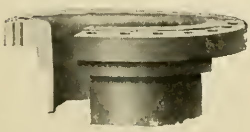
The Interlock Welded Neck
Patented

INTERLOCK WELDED NECKS

This method of connecting branch lines of wrought pipe to mains of the same material was developed in response to the demand of steam users for a structure containing the minimum number of joints. Every branch so connected eliminates a cast fitting with its attendant joints, gaskets and bolts and liability to trouble therefrom.

FLANGED JOINTS

Atwood, Screwed, Shrunk, Expanded and Welded.



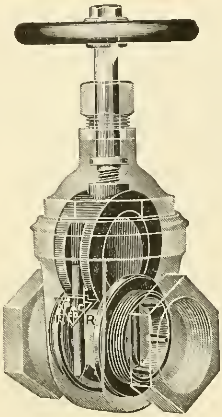
The Atwood Joint

ATWOOD

THE PRATT AND CADY COMPANY

HARTFORD, CONN.

VALVES FOR ALL PURPOSES



GATE VALVES

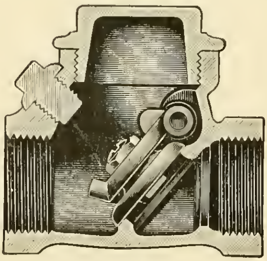
With renewable seat rings, held in place by a retaining ring that is easily removed.

Screw Hub, Stationary Spindle, Retaining Ring Construction.

The seat rings are independent rings of bronze, or any special metal or material best adapted for the service in which the valve is to be used. The gate is a double faced, wedge shaped casting, with side grooves by means of which it slides on guides in the valve body.

Great pains are taken in the machining of all parts of these gate valves. Gauges are used on each part to insure their accuracy and interchangeability.

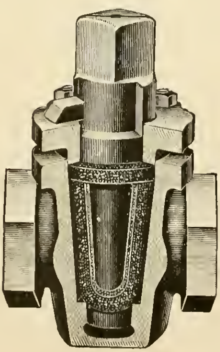
The guides in our bodies are of equal thickness, and the wedge can be taken out of the valve and replaced with the opposite faces in contact, and will give an accurate fit. The importance of this in making repairs is obvious. These valves being double seated, can be used with the pressure applied at either end.



REGRINDING SWING CHECK VALVES

Brass and Iron

All styles for all pressures, sizes up to 48 inches. The *Design* combines pressure resistance with easy flow lines. Material (of brass valves) is 86% pure copper. We use no scrap in their production. *Workmanship* — Each valve is individually tested to the pressure stated in catalog. All seats are carefully ground. Assembling is done by our most careful hands. The *Interior Construction* permits the replacement of any working part without removing valve from line. *For Regrinding* no tool is necessary but a wrench and brace and bit.



ASBESTOS-PACKED COCKS

The dovetailed U-shaped grooves in the body are packed with prepared asbestos. An asbestos ring is used on the shoulder of the plug for top packing.

The plug is of standard taper carefully finished and barffed to render it rustless. It has no metallic bearing, coming in contact only with asbestos, the elasticity of which compensates for the differential expansion and contraction of the plug and body. The gland admits of adjustment by means of its bolts.

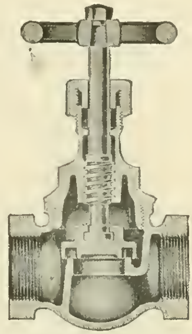
These cocks give exceedingly satisfactory results as a boiler blow-off and a water column blow-off, between check and boiler, between water column and boiler, and they do work where ground plug cocks are unsatisfactory and where Globe, Angle or Gate Valves fail.

THE PRATT AND CADY COMPANY

HARTFORD, CONN.

VALVES FOR ALL PURPOSES

ASBESTOS DISC VALVES



The Stuffing Box Gland is long, heavy and well fitted.

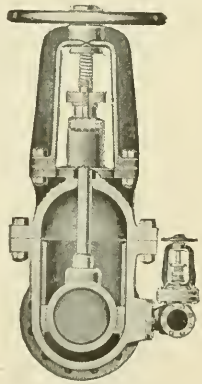
The Spindle Collar, and its point of contact with the bonnet, have specially smooth surfaces and make a steam-tight joint when valve is fully open.

The Disc Holder is guided by four splines in the body, assuring perfect alignment at all times. The Disc Holder is of the horseshoe type, and can be removed and replaced, the only tool necessary therefor being a wrench to unscrew the bonnet.

The Seat is spherical, thus preventing the settling thereon of any substance that might hold the disc from going squarely to its place. The metal used in the construction of these valves is approximately 86% pure copper. We use no scrap whatever in the construction.

The Valve complete is finished with the utmost care. When so ordered, these valves can be made with solid brass disc, or with brass disc holder filled with special metal, at additional price.

CAST STEEL GATE VALVES FOR SUPER-HEATED STEAM



All Valves 2½″ and larger are equipped with Cast Steel Bodies, Bonnets and Wedges.

The Seats and Faces of the Wedges are made of Nickel, securely fastened in place so that they will be unable to work loose.

Stems are Nickel Steel.

All Bolt Holes are Spot Faced.

Bonnet Joint is packed with the best grade of Superheat Packing.

The End Flanges have $\frac{1}{16}$″ Raised Faces, extending full width inside of Bolt Holes, with smooth finish.

All Bolts have Hexagon Heads and Nuts, with the under side of same semi-finished.

The Discs are of the Wedge Pattern.

Stuffing Box is made with Hinge Bolts, very deep for square Packing.

Yoke is bolted to the Bonnet.

All tested to a hydrostatic pressure of 800 lbs.

COMPRESSION TYPE HYDRANTS

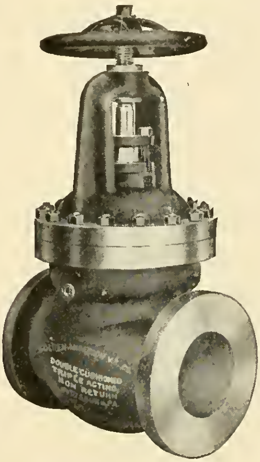
Without Intricacy of Construction.

Complete catalog of all Pratt and Cady products on request.

GOLDEN-ANDERSON VALVE SPECIALTY CO.

1218 FULTON BLDG. PITTSBURGH, PA.

STEAM AND WATER SPECIALTIES



Triple Non-Return Valve

AUTOMATIC DOUBLE-CUSHIONED TRIPLE-ACTING NON-RETURN VALVES

(Angle or Globe)

"Works Both Ways;" automatically protects the boilers and steam lines.

They will prevent one boiler working at a lower pressure than another; also should a tube burst, they will instantly shut off the flow of steam from the other boilers into the injured boiler.

The Automatic Safety Stop Feature protects life and property in case a break or rupture occurs in the main steam line or branches. The valves will automatically cut off the flow of steam from the boilers until the break is repaired.

1128 of these were ordered by the U. S. Steel Corp. for the protection of their power plants.

Made in sizes 2 inches to 24 inches.

Controlling Altitude Valve

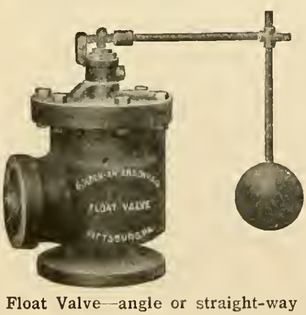
THE CONTROLLING ALTITUDE VALVES

These are intended for automatically maintaining uniform stage of water in tanks, standpipes or reservoirs and do away with the annoyance of floats or fixtures. They are especially adapted for water works and railroads.

These valves can be used with either high or low pressures and may be closed automatically by water, by electricity or by hand.

In addition to the type illustrated we build valves with electrical attachments that can be quickly closed by means of a direct or alternating current. The solenoids are attached directly to the valves and wired up to switch at pumping station or switches at various locations, thus permitting instant operation.

Altitude Valves are made in either the angle or globe pattern, in the following sizes: 3, 4, 6, 8, 10, 12, 14, 16, 18, 20 and 24 inches.



Float Valve—angle or straight-way

AUTOMATIC FLOAT VALVES

The Pat. Automatic Angle and Straightway Float Valves are also intended for controlling water levels in tanks, standpipes or reservoirs. They can be instantly adjusted to operate quickly or slowly.

When in operation, the water comes in under the valve or piston, also through port on top of valve. Owing to the greater area above the valve it is held closed. When lever is operated by float the auxiliary valve closes the inlet port and opens exhaust port.

Owing to the pressure on top of the valve being removed, the pressure under valve forces it open. The water above the valve acts as a cushion in opening, and as the valve travels upwards it draws in air through ports in the side of the body to cushion the valve when closing. Made in the following sizes, for either high or low pressures: 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20 and 24 inches.

S. F. BOWSER & COMPANY, Inc.

Established 1885

HOME PLANT AND GENERAL OFFICES, BOX 2167, FORT WAYNE, IND.

BRANCHES

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Albany	Atlanta	Chicago	London	Paris
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Sales offices in all Centers and Representatives Everywhere

OIL SYSTEM ENGINEERS, PATENTEES AND MANUFACTURERS

Oil System Engineers, Original Patentees and Manufacturers of:

Oil Storage and Distributing Systems.

Self-Measuring Hand and Power Driven Pumps.

Underground Storage and Distributing Systems.

Large Tankage.

Automobile Filling Stations.

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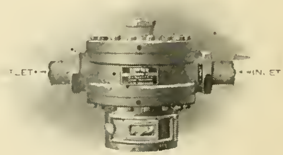
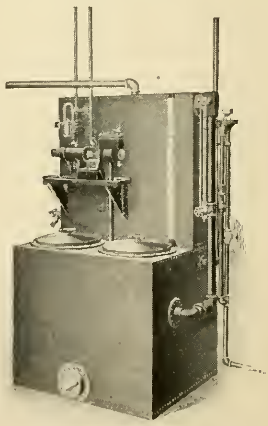
Self-Registering Pipe Line Measures.

Oil and Gasolene Storage and Distributing Outfits for Public and Private Garages.

Oil Filtering and Circulating Systems.



Registering Measure



Oil Filtering System

A Representative Oil House

The Bowser line covers every requirement of the factory and railroad for oil storage equipment.

Our corps of mechanical and drafting engineers is at the command of those interested in this line.

Bulletins giving complete detailed description of any line will be furnished upon application and without obligation. We have a fund of information on oil storage and allied lines that will assist in making up specification for this work. Let us submit it.

Our catalogue illustrates and describes the line in a limited way and shows a large number of installations in widely diversified fields.

GREENE, TWEED & CO.

109 DUANE STREET, NEW YORK

MANUFACTURERS OF THE ROCHESTER AUTOMATIC LUBRICATOR

Vacuum and Check Valve

The Lubricator, in the manufacture of which no expense has been spared, efficiency and high quality being our aim rather than low prices.

For the lubrication of the cylinders of all types of steam engines and pumps as well as air and ammonia compressors.

Made in all sizes from one-half pint to two gallon and with any number of feeds from one to eight. Also made with two compartments, for use where different kinds of oil are used in the different cylinders of the same machine, such as air compressors, ice machines, etc.

Finish-all sizes above one-half pint fully nickel-plated, one-half pint size, japanned body.

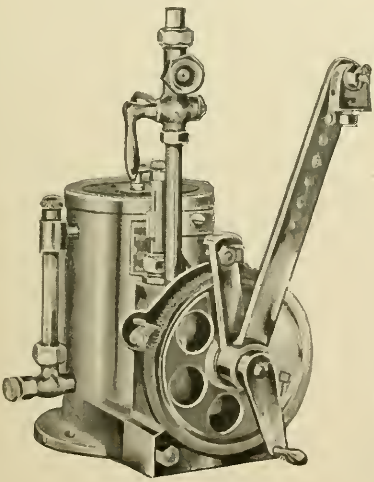
Working parts are made of steel, and all bearings are case hardened.

All the mechanism can be instantly detached and removed, giving easy access to the working parts for cleaning, repairing, etc., without disturbing the bowl or reservoir attached to the engine.

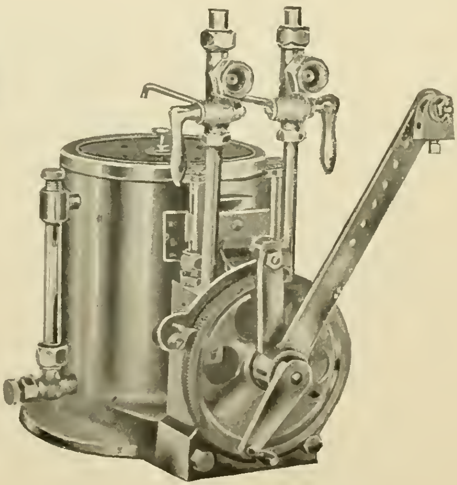
Equipped with Multiplus Sight Feeds, and vacuum and check valves.

Each feed is regulated independently.

Not affected by temperature, pressure or vacuum.



Single Feed



Double Feed

"PERFECT FORCE FEED LUBRICATION"

THE TEXAS COMPANY

NEW YORK AND HOUSTON

MANUFACTURERS OF LUBRICATING OILS, ENGINE AND MACHINE OILS AND GREASES. LUBRICATING OILS PREPARED ESPECIALLY FOR USE OF TURBINES, GRAVITY-FEED AND FORCE-FEED SYSTEMS UNDER ALL CONDITIONS.

In the modern power plant the question of lubrication is one of vital importance. It is a question which, affecting as it does the general efficiency of the entire plant, cannot be decided off-hand.

Before an entirely satisfactory solution is reached great care and study are required on both the part of the consumer and the manufacturer. The consumer must be careful to the utmost in his selection and employment of an oil. The manufacturer must devote himself to the study of conditions and methods of lubrication to be in a position to meet consumer requirements.

This last represents the part played by The Texas Company in the field of lubrication. A careful consideration of consumer requirements combined with our extraordinary facilities—a high class organization and excellent crudes to work with—has placed The Texas Company in a position to furnish lubricating oils that display high efficiency in checking friction and promoting economic operation.

In the larger plants lubrication is a problem carrying extra gravity, due to the severer conditions of work and it is here that the value of TEXACO LUBRICANTS is most forcibly demonstrated.

TEXACO LUBRICANTS are peculiarly fitted to meet severe conditions. They lubricate perfectly, separate readily from any water that may get into the oil through leakage and they stand up well under severe work, maintaining as high lubricating properties after a thousand hours as shown when the oil was new.

Another very essential feature that contributes to the general excellence of TEXACO LUBRICANTS is their low cold test. This is especially important in large stations where the oil is pumped from a central filtering plant to the engine. It will eliminate the shutting down of the station in cold weather on account of the oil having congealed.

The TEXACO OILS for general, rolling-mill and manufacturing plant lubrication are of such a nature that great economy will result in their use. Every requirement of lubrication, whether power economy, general plant economy, or cost can be met by TEXACO LUBRICANTS.

We publish a quarterly—"Lubrication." It ought to contain something of interest to you. It's yours for the asking.

Address Department M. E.

17 Battery Place, N. Y. City.

THE TEXAS COMPANY.

THE METALLIC PACKING & MFG. CO.

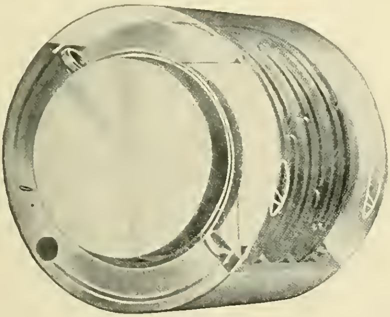
L. H. MARTELL, Mechanical Engineer & Gen'l Manager

ELYRIA, OHIO

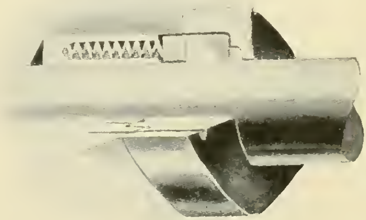
MAKERS OF MARTELL PACKINGS

MARTELL METAL PACKINGS

Martell Metal Packings embody the results of more than twenty years spent in design, manufacture, sale and use of all kinds of packings. They are made to meet all conditions and are in successful use in connection with steam, gas, water, oil and chemicals of various kinds.



For steam piston rods in ordinary size and service



For Corliss valve stems

The wearing rings are made of cast iron or bronze for piston rods and of red metal or high grade babbitt for the valve stems, all permanent parts being rigid and substantial. The illustrations herewith show two (2) of the most simple of our numerous designs. Packings are placed as conditions seem to warrant, accessibility being kept in mind at all times.

These Packings are made for rods or stems from ⅝ to 18 inches in diameter, and for plungers up to 36 inches; they are entirely self contained, and so simple that no special skill or experience is required to install. Both piston rod and valve stem Packings float freely and easily with any side motion of the rod or stem. Packing rings for Corliss stems are contained in permanent part, all of which revolves with stem.

We also manufacture the Horton Gas Engine Packing, designed and patented by Mr. James Horton, Efficiency Engineer of the Homestead Works of the Carnegie Steel Company, Pittsburg, Pa.; Twentieth Century Metal Packing Rings; Martell Metal Hydraulic Packing for outside center packed pumps; Martell Metal Hydraulic Packing for step bearing pumps, and Martell Locomotive Packing. The latter holds the mileage record on Engines using superheated steam.

All Packings are strictly guaranteed and will be placed on approval.

THE SCHAEFFER & BUDENBERG MFG. CO.

BROOKLYN-NEW YORK

CHICAGO WASHINGTON PITTSBURGH

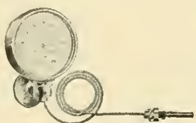
INSTRUMENTS FOR MEASURING, INDICATING, AND RECORDING, TEMPERATURE, PRESSURE, AND SPEED

"Crescent" Thermometer

"CRESCENT" THERMOMETERS

We are pioneers in the manufacture of industrial Thermometers of every description. Among our line of high grade "Crescent" Thermometers will be found an instrument for practically every purpose, and our catalog No. 27 illustrates over seventy types. Handsome in appearance, faultless material and perfect in mechanical detail and construction.

Specify size of scale case desired, graduation, character and size of connection, character and length of stem, and the purpose for which the thermometer is to be used.



"Reform" Thermometer

"REFORM" THERMOMETERS

A dial face, *mercury filled*, indicating thermometer having the accuracy of the standard glass tube thermometer and the conveniences of a dial face instrument. Entire working mechanism is made of steel, meaning long life. Standard size of dial 6 inches. Other sizes made to order. Furnished with either rigid connection or flexible capillary steel tube connection. The latter greatly facilitates installation. State the graduation desired, character and length of connection, and the purpose for which the thermometer is to be used.

"Columbia" Recording Thermometer

"COLUMBIA" RECORDING THERMOMETERS

Acknowledged to be the most simple, yet the most reliable type of Recording Thermometer. *Mercury actuated*, therefore absolutely accurate. Steel construction throughout combining *extreme strength and durability* with accuracy. Uniformly graduated, wide and effective ranged charts with the popular day and night border, made in two sizes, 8″ and 12″ respectively, for 24 hours or 7 days. Furnished with either rigid connection or flexible steel protected steel capillary connecting tubing of any length.

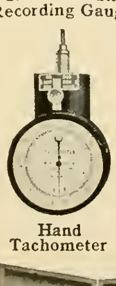
State size of chart and graduation, length and character of connection and the purpose for which the recorder is to be used.

The Columbia Recording Gauge

THE COLUMBIA RECORDING GAUGE

The "Gem" of Recording Gauges. Its chief feature is its great reliability, then comes its wonderful durability. Thousands in daily use. Adapted for any purpose. In portable and stationary types, for 8″ and 12″ day and night charts respectively, making one revolution in 24 hours or 7 days as desired.

State size of chart and graduations, and the purpose for which the Recorder is to be used.

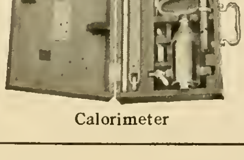


Hand Tachometer

TACHOMETERS

We have a most complete line of Hand and Stationary Tachometers, and we have recently added many new styles and types, covering absolutely every requirement met with in practice. Constructed on the most modern principles, accuracy guaranteed, compact and durable in construction, perfect in mechanical detail and handsome in appearance.

State desired graduations and if Stationary type of Tachometer is wanted, the diameter and the normal speed of the shaft you will drive from.



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We manufacture Professor Carpenter's pattern Calorimeters for Steam and Coal. The throttling type of Steam Calorimeter serves for determining the amount of moisture contained in saturated or superheated steam, while the Separating type is designed to show the percentage of water by mechanical separation of the water from the steam. The Coal Calorimeter is of great value in Power Plants as it determines the calorific power of coal almost directly in B. T. U.

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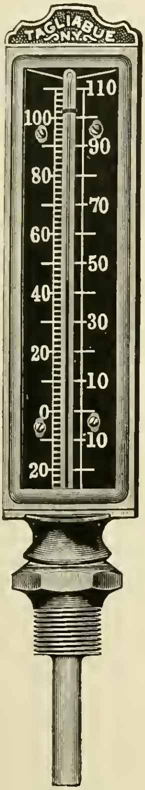

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MERCURIAL THERMOMETERS

Hohmann-type, as well as types of lower quality, in various sizes, forms and scale-ranges as required for the particular applications to

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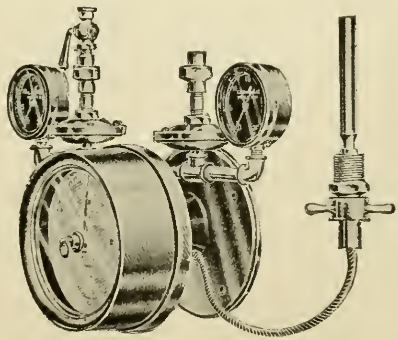

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THE

JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JUNE 1913

35 CENTS A COPY $3 A YEAR

MEETING IN GERMANY: JUNE 21–JULY 8

A NEW ENGINEERING GRADE

To provide for an increasing number of engineers who attain positions of authority earlier than is prescribed in the requirements for Members, the Constitution has been amended, for the establishment of a new grade, that of *Associate Member*, intermediate between Junior and Member. This will permit men of attainment to join immediately who otherwise would not, preferring to wait till they could secure Member's grade, with the chances of not following their intentions as early as they ought and thus losing contact with the profession, and the publications and the acquaintanceship of the Society.

Juniors are able to secure recognition of progress in the profession earlier than they otherwise would.

This is a *professional and engineering grade* and the requirements are as follows:

An ASSOCIATE-MEMBER *shall be an Engineer* or a Teacher of Applied Science of twenty-five years of age or over. He must show by his experience or by his duties that he is competent to execute work in his profession.

To obtain promotion to a higher grade application should be made in the same manner as for admission, forms for which will be supplied by the Secretary or upon request of any of the Committee.

The old *Associate* grade is intended for non-technical men-of-affairs, presidents and employees of engineers.

An ASSOCIATE shall be thirty years of age or over. He *need not be an engineer,* but must have been so connected with some branch of Engineering or science, or the arts, or industries, that the Council will consider him qualified to coöperate with Engineers in the advancement of professional knowledge.

MONTHLY ELECTIONS

Another of the amendments just adopted provides for election of candidates at the regular monthly meetings of the Council instead of semi-annually as formerly. The new method will materially reduce the time required for action on applications for membership.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

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Cincinnati, J. T. Faig	*St. Paul*, Max Toltz
Cleveland, R. B. Sheridan	*San Francisco*, Thos. Morrin
Michigan, H. W. Alden	*Seattle*, R. M. Dyer

JUNE 1913 VOL. 35 No. 6

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CONTENTS

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VOL. 35 JUNE 1913 NUMBER 6

SPRING MEETING

The meeting at Baltimore was in every way a successful gathering. The Society and its friends were the guests of the Engineers' Club of Baltimore, with whom the local members of the Society and the officers at Annapolis coöperated to the fullest extent; and the work of the local committees under the direction of the Executive Committee of the Engineers' Club was planned and carried out with such nicety of detail as greatly to enhance the enjoyment of all in attendance.

The registration was small as had been anticipated, in view of the approaching German Meeting, there being 142 members present and 185 guests. There have seldom been professional sessions at any of the Society's meetings, however, at which there was greater sustained interest or more effective discussion.

It was the purpose of the Committee on Meetings to make the trial this spring of fewer sessions than usual for the discussion of papers, a plan which appeared to meet with general approval. After a strenuous winter's work, the conditions are more propitious for relaxation and enjoyment of one's friends at a spring convention than for the reading of technical papers. On the other hand, there has recently been a marked increase in the number of papers presented at annual meetings in December, so that no diminution in the total number of papers for the year is anticipated.

The Belvedere, which was the headquarters for all the Baltimore sessions, is ideal for the purpose. The whole top floor is given up to assembly rooms well adapted either for social or professional needs.

TUESDAY EVENING RECEPTION

On Tuesday evening, May 20, was a gathering in the tea room of the Belvedere for an informal reception by the officers of the Engineers' Club of Baltimore and an address of welcome by the Mayor of Baltimore, Honorable James H. Preston.

The speakers were introduced by the President of the Engineers' Club of Baltimore, Mr. R. Keith Compton. In welcoming the guests to the city the Mayor dwelt on the importance of the present day work of the engineer and especially on the importance of his work in connection with the municipal improvements of the city of Baltimore. During a period beginning six or eight years ago some of the most important features of the city have been entirely rebuilt, and will when finished constitute a series of municipal improvements almost unprecedented in their extent.

Following the great fire, from the effects of which the city arose without outside aid, came the construction of the high-pressure fire system and there is now under way a large extension of the water system for general use, the construction of what is judged to be the finest sanitary sewerage system in the world, and many miles of the city streets are being re-paved. Other and extensive improvements have recently been completed or are contemplated, such as the municipal docks and police department buildings.

As the President, Dr. Goss, did not arrive until later, Past-President Oberlin Smith responded for the Society, outlining briefly the growth of the engineering profession from the days of the military engineer to the present time when engineering interests are so diversified that there are many established branches, represented by the four national engineering societies of today.

A few remarks upon engineering, past and present, with reminiscences of early days in Baltimore, were made by Mr. Mendes Cohen, Past-President of the American Society of Civil Engineers, and Honorary Member of the Baltimore Engineers Club.

BUSINESS MEETING, WEDNESDAY MORNING

The semi-annual business meeting was held on Wednesday

morning with the President, Dr. W. F. M. Goss, in the chair. The Secretary announced the result of the membership ballot by which 605 names were elected to membership of various grades. Of these 547 were new and the balance were promotions. This is the largest ballot in the history of the Society as a result of the splendid efforts of the Increase of Membership Committee and of many individual members who have personally aided in the work; and is all the more gratifying because of the high professional standing of these accessions as shown by the professional record pamphlet which has been distributed to the membership.

Announcement was further made of the membership ballot on amendments to the Constitution, which relate chiefly to the establishment of a new grade to be known as "Associate-Member" and to the method of election of members. An Associate-Member must be an engineer or a teacher of applied science, 25 years of age or over, and competent to execute work in his profession. This grade differs from what is now known as an "Associate" in that it is required that the candidate be 30 years of age or over and qualified to coöperate with engineers. The new method of election as explained more fully elsewhere in this issue, is by ballot of the Council instead of by ballot of the membership at large.

Under the order of new business, notice was given of the recommendation by the Council that the constitution be further amended with respect to the grades of Member and Associate-Member, in each case raising the requirements. Under the proposed plan a Member will have to be 32 years of age or over and must have been in active practice of his profession for at least 10 years and in responsible charge of important work for five years; or if a teacher, equivalent experience will be required as a professor of engineering in charge of a department. To become an Associate-Member a candidate must be at least 27 years of age, with six years' professional experience and one year in responsible charge of work. The Secretary explained that by this new grading a Member would have the same rank as the recently established "Fellow" in the American Institute of Electrical Engineers and an Associate-Member would correspond to the "Member" in that organization.

A resolution was interposed by W. J. Andrews in reference to a suitable headstone or monument to mark the grave of John

Fitch. The career of Fitch and an account of the running of his boat on the river at Philadelphia in 1790 was published in The Journal at the time of the Hudson-Fulton celebration, and it appears from advertisements of that time that passengers were carried, making this the first American passenger boat to be propelled by steam. It was voted that the matter of marking the grave be referred to the Council for appropriate action.

The meeting then proceeded to the hearing of reports of committees. That upon the Myriawatt was presented by Mr. H. G. Stott, Chairman of the Committee on the Myriawatt, who replied to the criticisms by Messrs. William Kent and George H. Barrus which were published in the May issue of The Journal. Mr. Stott's reply, with the other discussions upon the Myriawatt, will appear in a later issue of The Journal.

A Code of Ethics for engineers, published in the January issue of The Journal, was presented by Charles T. Main. In the discussion it was objected to in its entirety by Fred H. Colvin and in part by Richard H. Rice, who held that Par. 8 of the report would tend to encourage the upholding of men who had given wrong advice, and that Pars. 23 and 24 limited the advertising methods used by engineers.

Mr. Stott explained that the Code of Ethics was intended to help out young men who lacked the experience of older engineers and indicate to them a proper method of procedure in their professional relations. He did not favor establishing strict lines, but believed that a code of ethics would prove useful to young men who had not had these points of practice driven into them by hard experience.

It was proposed that the report be submitted to the membership at large and after considerable discussion as to what recommendation to make to the Council in this regard, resolutions were finally passed in the following form:

Resolved: That this meeting approves in general the proposed Code of Ethics for adoption by the Society.

Resolved: That it be recommended to the Council that the proposed Code of Ethics be printed in pamphlet form and a copy be mailed to each member of the Society, accompanied by a ballot so prepared that each member may vote upon each clause separately; and that if the majority of those voting are in favor, this Meeting recommends that the Council shall declare the report approved and shall arrange for the appointment of a committee on the interpretation of the code.

A third report to be presented was the majority report of the Committee on Standard Involute Gears. Owing to the absence of the chairman of the committee at that time, the reading of the report was deferred until later in the morning. This report and the discussion upon it will be printed later.

PROFESSIONAL SESSIONS

Following the discussion upon the reports came the first professional session with the following list of papers:

Test of a Hydraulic Buffer, Carl Schwartz

The Present Condition of the Patent Law, Edwin J. Prindle

Shading in Mechanical Drawing, Theodore W. Johnson

Cost of Upkeep of Horse-Drawn Vehicles against Electric Vehicles, W. R. Metz

It was decided to assign the single Gas Power paper on Present Operation of Gas Engines using Blast-Furnace Gas as Fuel by Charles C. Sampson, which it was expected would be presented at a separate session of the Gas Power Section, to one of the regular meetings of the Society and this came up for discussion on Thursday morning.

But two professional sessions, therefore, were held, the second on Thursday morning being devoted to the subject of fire protection with the following list of papers:

The Baltimore High-Pressure Fire Service, James B. Scott

National Standard Hose Couplings and Hydrant Fittings for Public Fire Service, F. M. Griswold

Debarment of City Conflagrations, Albert Blauvelt

Allowable Height and Area in Factory Buildings, Ira H. Woolson

The Protection of Main Belt Drives with Fire Retardant Partitions, C. H. Smith

The Life Hazard in Crowded Buildings due to Inadequate Exits, H. F. J. Porter

The discussion at both of these meetings was spirited and interesting and will be reported fully in later issues of The Journal.

On Wednesday morning the paper by Mr. Prindle on The Present Condition of the Patent Law pointed out that the decision of the Supreme Court in the "Mimeograph Case" sustaining the right of the patentee to require the purchaser of the

machine to buy of the patentee ink and paper for use on it had resulted in the introduction of a large number of bills in Congress with a view to cutting down the patentee's monopoly. It explained the general nature of the proposed legislation and its effect on the patent law and upon inventors. Upon motion of the author the following resolution bearing upon this matter was passed:

Resolved: That the Council be requested to take appropriate action against the amendment of the Patent Law and the bills now before Congress until a competent commission shall have reported on the advisability of the proposed changes.

CONFERRING OF HONORARY MEMBERSHIP UPON CAPTAIN CHARLES HENRY MANNING

An event that gave pleasure to all was the conferring of Honorary Membership upon Captain Charles H. Manning known for so many years as the mechanical superintendent of the Amoskeag Manufacturing Company, Manchester, N. H. Captain Manning was born in Baltimore, Md., in 1844. He received his engineering education at the Lawrence Scientific School of Harvard University and during the Civil War was in service on various ships. The war ended, there followed a period of sea duty in different parts of the world until, in 1870, he was assigned to shore duty as instructor at the Naval Academy at Annapolis.

After twelve years of continuous service there he was granted a leave of absence and took charge of the reorganization of the steam and water power plants of the extensive Amoskeag Mills at Manchester, N. H. He later resigned from the Navy, his name being placed on the retired list in 1884.

Introducing Mr. Manning at the meeting, Dr. Goss said:

The audience has the rare privilege of counting among its numbers Charles H. Manning, one of our most distinguished engineers, who is still a retired officer of the Navy with the rank of Lieutenant-Commander and Chief Engineer. He rendered conspicuous service to the country before his retirement, and since then in the cotton mill industry of New England. He was a pioneer in centralizing power in large stations, and his efforts with the Amoskeag mills of New Hampshire brought about the conversion of sundry stations into a single station supplying steam over a large area. He is the inventor of the Manning boiler and is an authority on water power. In December last he resigned from the active direction of the engineering work of the Amoskeag mills. He is a much beloved member of this Society, of which he has been an active member since 1884. In recognition of this fact the Council has taken unusual action in bestowing Honorary Membership upon Mr. Manning.

Mr. Manning, in recognition of your great ability as an engineer, of your great character as a man and of your abiding loyalty to the profession of engineering and to the members of this Society, a petition signed by twelve members was presented to the Council at its March meeting. This petition was a document of unusual significance. The first name on the list of signers was that of Benjamin F. Isherwood, chief engineer of the Navy during the Civil War, and the last name that of Erasmus D. Leavitt, the second President of this Society, the others upon the petition being names of distinguished engineers. Acting upon this petition, the Council, having given due consideration, unanimously voted by a letter ballot to confer upon you the rank of Honorary Member, in token whereof I have the privilege this day to present you this certificate.

Captain Manning said in reply:

This is a great surprise to me and I fully appreciate the honor, coming to me as it does in my native city. I was born two or three blocks from here and raised under the shadow of the Washington monument. After what schooling I had away from here, I returned here early in the Civil War to commence my practical engineering experience, and yesterday on the boat that took you down the River I met one of my old shopmates of 52 years ago.

I have been a member of this Society from the early beginning, when we had a second story room in the library down on lower Broadway, and my old friend, Thomas Rae, was then secretary. I have always been interested in the work of the Society, have done what I could to promote it, and have enjoyed the friendship of many of the presidents, John Sweet, Loring, Melville, and that greatest of all, John Fritz, with whom I had the honor of being on very friendly terms.

The old organization has had my love and respect, and my one honor is that I have helped the cause of mechanical engineering in this country as one of the instructors at the Naval Academy in Annapolis. I spent eight of the happiest years of my life there, and I consider my work there for mechanical engineering as the greatest I have ever done. Judge by its results, for amongst my pupils were Professors Hollis, Spangler of Pennsylvania, one of our honored members who has now gone before, Cooley, Durand, and a half dozen others of the distinguished members of this Society. They had not very much use for me then, but a better set of friends I have never had anywhere in the world.

I thank you one and all for this honor.

RESOLUTIONS OF THANKS

At the close of the Thursday morning session, the following resolutions of thanks were unanimously passed:

WHEREAS, The American Society of Mechanical Engineers, in session at its semi-annual meeting, in Baltimore, Maryland, May 20 to 23, 1913, has enjoyed so profitable and delightful a visit through the efforts of the Engineers' Club of Baltimore, and of the Local Committees.

BE IT RESOLVED, That the secretary be instructed to extend the thanks

of the visiting members and guests to all who have contributed to their entertainment; to the Engineers' Club of Baltimore for their cordial hospitality; to the Executive Committee of the Committee on Entertainment, Layton F. Smith, Chairman; to the Chairmen of the various sub-committees on entertainment; to the Citizens' Committee; to the Ladies' Committee, Mrs. J. W. Shirley, Chairman; to the Committee on the visit to the U. S. Naval Academy, Prof. T. W. Johnson, Chairman; to his Honor the Mayor of Baltimore, James H. Preston, and the City Council for the demonstration of the high-pressure fire system and the use of the ice boat, F. C. Latrobe, for the trip around the harbor; to his Excellency, Governor Goldsborough, for his welcome to the State of Maryland; to Lieutenant-Commander H. I. Cone, U. S. N., for his address; to Captain Gibbons, U. S. N., Commandant of the U. S. Naval Academy, for the courtesies extended during the trip to the Naval Academy; to the Arundell Club for the use of their rooms and courtesies extended to the visiting ladies; to the various manufacturing plants that arranged trips of inspection; and to the owners of automobiles who loaned them for the use of the guests.

THE TRIP TO ANNAPOLIS

On Friday the whole day was devoted to a visit to Annapolis, the "colonial city," and to an inspection of the Naval Academy and the Government Experiment Station. The trip was made by the W. B. & A. electric road and upon arrival the party assembled at the historic State House where Washington resigned his commission as commander-in-chief of the Continental Army. The Society was received in the assembly hall by Governor P. R. Goldsborough, who welcomed them with a brief address in which he typified Annapolis as the Athens of America and referred to the beauty of the colonial buildings and the symmetry of their lines of architecture. He said that we all gratefully remembered the loyal patriots with whose names so much of historic Annapolis is associated, particularly the four signers of the Declaration of Independence whose residences still stand, Samuel Chase, Charles Carroll, Thomas Stone, and William Paca, the house of the last-named now being Carvel Hall. There is also the liberty tree, the largest tree on the Atlantic coast, under which the patriots met to protest against British domination. In the State House Congress ratified the treaty with Great Britain at the close of the Revolution and action was taken leading to the adoption of the Federal Constitution.

Dr. Goss said that it was fitting to ask Prof. Ira N. Hollis, long associated with the Naval Academy, to respond to the welcome so cordially extended by his excellency the Governor. Professor Hollis spoke as follows:

The kindness of Professor Goss has placed upon me the agreeable honor of thanking his Excellency, Governor Goldsborough, on the part of the President and members of The American Society of Mechanical Engineers, for this cordial and generous welcome to the State. We shall leave Baltimore with a most pleasing memory of the hospitality of Maryland and of the excellent judgment of that small committee of its citizens who made the plans for our visit. But this reception in the State House will add something of a deeper nature to our feelings. Here we are closer to the great man who gave up his sword to become for all time the ideal of American citizenship. We are eager and glad to think that his early career began in a branch of engineering, and in that belief, we shall carry with us to all parts of the Union a new dedication to our profession and to the service of our fellow countrymen. In this sense, Maryland has shown us that higher example of service which every engineer should rejoice to follow; and his Excellency as the representative of his State has given us an enduring satisfaction in the permission to use a room in this historic State House for our meeting in Annapolis.

The President and members of this Society express to his Excellency their wishes for his continued success, and to the State of Maryland their pride in its career. Wherever one of us shall go when we scatter this afternoon to all points of the compass, there will the Governor and the citizens of this State find a sphere of influence. Our hope is that they may soon come to let us show them the warmest center. Long live this generous commonwealth.

Following these remarks came an address by Lieutenant-Commander H. I. Cone, U.S.N., late engineer-in-charge of the naval experiment station at Annapolis.

ABSTRACT OF ADDRESS BY LIEUTENANT-COMMANDER CONE

On July 18, 1861, Congress passed the following Act:

SECTION 1537. No patented article connected with marine engines shall hereafter be purchased or used in connection with any steam vessel of war until the same shall have been submitted to a competent board of naval engineers and recommended by such board, in writing, for purchase and use.

This indicates that the business of conducting experiments on board war vessels in commission was being overdone, and in view of the fact that war had begun and the ships were needed for serious business, it was thought desirable to do the experimental work on shore.

From that time, boards of engineer officers have been appointed from time to time to make practical tests of various machines and devices offered to the navy. This work was generally done at a navy yard with such appliances as were available or could be purchased at short notice.

Naturally, among the many schemes submitted there would occasionally be one that merited serious attention, in which case the test was ordered to be made at some navy yard, either by a board or by the engineer officer of the yard, the applicant for the test paying the actual cost of labor and material as provided by law.

As time went on, however, and the navy expanded, the number of ships under repair at the yards increased, and it became more and more difficult to carry out these tests. Often a rush order would come from Washington to concentrate all force on some particular ship and get her off to sea at once. Then a test, whatever it might be, would be dropped hastily and much of the work previously put on it would be wasted, the experimenters discouraged, their interest lost.

This went on for years and George W. Melville, then engineer-in-chief, tried in vain to get an appropriation for a special experiment station where experimental work would be paramount. Finally, during the enthusiasm for the navy immediately following the Spanish War, about $10,000,000 was appropriated for the rebuilding of the Naval Academy and with it $400,000 for the much desired and greatly needed experiment station building and equipment, it being proposed to locate it in the Naval Academy grounds, and the law specifically requiring that it be located in that vicinity.

One of the aims of the experiment station is to intercept all sorts and kinds of new devices and inventions intended for use on naval vessels, or thought suitable, and sort out from this great and varied mass the few that (by long tests, specifically applied to discover their applicability and desirability for use on shipboard) are found available. The tests are made by officers who from experience are especially able to decide whether the machine or appliance under investigation is suitable for use on naval vessels, whether it could be operated successfully by the class of men usually available among the ships' crew and whether it could be kept in operation under the circumstances and conditions as they commonly exist on war vessels. These officers naturally hold the good of the service as of infinitely more importance than the success of an inventor's favorite scheme, however ingenious and interesting it may be in itself. Also they are as keenly interested in getting for the navy anything superior to that it supplants as they are firm in rejecting something that will

give endless trouble to others and quite possibly to themselves when their time comes to go to sea.

Another activity which has taxed the resources of the station is that of testing all sorts of material for use in the navy as to its relative value in addition to determining its safety and availability for naval use. Owing to law and regulations requiring that contracts be awarded to the lowest bidder on a suitable article, the Bureau of Steam Engineering has been confronted for years with confusing questions as to the suitability and quality of a great many ordinary machinery supplies. The station has in the past and is at present solving a great many of these questions, and at the same time making it fairer for the bidders as well as much more economical for the government.

Another aim and the reason for the establishment of the station at the Naval Academy is the fact that such a laboratory will be valuable for the instruction of midshipmen. The Naval Academy is now primarily a military engineering school, and this should be evidenced by the extent of the installation and the facilities for conducting research work at Annapolis, as well as by the character of the instruction imparted.

The experiment station is now also being utilized as an auxiliary to the post-graduate course in engineering. This work is essential to naval efficiency, and is earnestly desired by many junior officers of the service. Post-graduate work in engineering is absolutely necessary to secure the large complement of ordnance, electrical, radio, and engineering experts that will be needed in the near future.

There are also various classes of research work that should be and often must be conducted under municipal or national auspices, and particularly is this the case with matters relating to maritime and naval affairs. As there is hardly a shipbuilding firm on the Atlantic or Pacific coast which has paid a dividend during the past ten years, it could not reasonably be expected that such commercial interests would seriously entertain the proposition of expending large sums of money for even important engineering investigation and research work, particularly if the resulting advantages could possibly accrue to the benefit of their rivals to nearly as great an extent as it did to those who conducted the tests at their own expense.

In the short time that the station has been under actual operation the research work has borne fruit beyond the expectations

of the most sanguine. In the matter of boiler corrosion and heat transmission alone a large expense has been avoided. The station is now furnishing its designers a considerable number of data, and it is hoped to extend these so that the designs and specifications will contain only the essentials to insure safe and durable machinery and supplies, while at the same time it is intended to use as many commercial articles as requirements will permit.

There is a still broader and more important sphere of usefulness that ought to be within the capabilities of a national engineering laboratory and that is to conduct experimental research along lines suggested by the great engineering societies of the country. There are fields of investigation that cannot be expected to be covered either by individual scientific institutions, corporate interests, or even by any single commonwealth, but which could be legitimately carried on by a national engineering research institution.

The active coöperation of this Society in this matter is not only desired, but is necessary to the development of the undertaking in its fulness. It is therefore to be hoped that before final adjournment, the Society will find it within the scope of its own purpose to make arrangements to confer with the Navy Department as to the best means by which the scientific organizations of the country can coöperate with the Navy Department in extending the field of usefulness of a national engineering laboratory that ought eventually to do much for engineering prestige, progress and advance.

INSPECTION OF POINTS OF INTEREST

There remained in the forenoon time for the inspection of historic points of Annapolis under the guidance of the young officers of the Naval Academy, after which lunch was served at Carvel Hall. The afternoon was spent at the Academy and nearly every one also went across the Severn River to the naval experiment station and the aviation camp. Four of the hydroaeroplanes gave demonstration flights which could be witnessed at close range. Rain prevented the concert by the Naval Academy band and the dress parade which had been arranged for.

DEMONSTRATION OF HIGH-PRESSURE FIRE SYSTEM

A feature of the meeting was the demonstration of the high-pressure fire system at the City Hall Plaza Wednesday after-

noon, and it was fortunate that the Society were able to arrange a meeting on Fire Protection on the following day to supplement this admirable exhibit of the capabilities of modern apparatus. Two automobile hose wagons were first used, from each of which four $2\frac{1}{2}$-inch streams from double lines of 3-inch hose were thrown from Monitor nozzles on the wagons; then twelve $1\frac{3}{4}$-inch streams with single lines of hose held by tripods were thrown; and finally one larger stream from a Monitor nozzle attached to a hydrant. Inspection of the pumping plant followed.

EXCURSIONS

Immediately after the demonstration of the fire system all joined in a trip about the harbor and down Chesapeake Bay, as far as Sparrows Point, by the municipal steamer F. C. Latrobe. It was a delightful trip and the committee in charge had arranged a typical Chesapeake Bay luncheon, the principal item on the bill of fare being steamed crabs, which had been caught that same day in the bay.

On Thursday afternoon many of the members took advantage of the opportunity to inspect the Jones Falls conduits, the sewage pumping plant, and the sewage disposal plant at Back River. This sewage system is being built at the expense of twenty million dollars. The storm water is delivered separate from the sanitary sewage directly into the bay, while the sewage is purified by bacterial treatment in the great disposal plant at Back River before being discharged.

On this afternoon also the ladies and many of the members as well took advantage of the generosity of the owners of automobiles who gave them a trip through the remarkably beautiful country surrounding Baltimore, all finally arriving at the Baltimore Country Club, Roland Park, where tea was served.

On the day previous the ladies had inspected the interesting manufacturing plants in the Coca-Cola Building and during their stay in the city were entertained also at the Arundell Club.

EVENING ENTERTAINMENT

On Wednesday evening was the usual lecture, given this time by Hon. O. P. Austin, Secretary of the National Geographic Society and chief statistician of the Department of Commerce. Mr. Austin has traveled widely and secured many beautiful views. His subject was Around the World in Eighty

Minutes, and a series of moving picture films were used, among them a roll belonging to the State Department showing recent work on the Panama Canal, loaned especially for the occasion by Secretary of State, Wm. J. Bryan. On Thursday evening the members and guests attended a dance and reception, with a late supper, given by the Engineers Club of Baltimore, which was the culmination of the several delightful social events of the meeting.

As mentioned at the outset the arrangements made by the various committees in charge of the entertainments had received much careful thought and were carried out with great completeness. Indicative of this was the printed matter issued; besides a program members were supplied with the beautifully printed Baltimore Book, issued by the municipality, an illustrated souvenir of Annapolis, and typewritten directions for all occasions, including notes on Annapolis, an outline of the automobile trips, and elaborate maps of Baltimore and vicinity.

GERMAN MEETING

The official party which will sail for Germany on June 10, to attend the meeting with the Verein deutscher Ingenieure in Leipzig, now numbers 243, and they will be joined in Germany by 45 others now abroad or sailing by other routes. A very complete guide book, containing the full itinerary, together with some account of the German society and the profession in general in that country, as well as of the cities and establishments to be visited, has been received and distributed to each of those who will participate in the trip.

Those in charge of the entertainment on board the S. S. Victoria Luise have the plans well under way. There will be sports of various kinds and log guessing and wireless contests, card parties, a mock trial, several lectures on German history, art, cities and educational systems by prominent members of the Society, a reception by the officers of the ship, a cotillion, a progressive dinner, and a cabaret performance. On Sunday, June 15, there will be religious services morning and evening.

The following committees have been appointed to care for the various features of the ocean trip:

ENTERTAINMENT COMMITTEE

Arthur M. Greene, Jr., *Chmn.*
Charles A. Mead
Geo. A. Orrok
H. G. Reist
Calvin W. Rice

ACQUAINTANCESHIP COMMITTEE

L. P. Breckenridge, *Chmn.*
William A. Doble
Lester G. French
James Hartness
H. G. Reist
J. E. Sague
Jesse M. Smith
Worcester R. Warner
E. H. Whitlock

LADIES COMMITTEE

Mrs. Arthur M. Greene, Jr., *Chmn.*
Miss Helen E. Armstrong
Mrs. Geo. M. Brill
Mrs. John R. Freeman
Mrs. Henry L. Gantt
Mrs. Frank B. Gilbreth
Miss Kate Gleason
Miss Alice Meier
Mrs. Jesse M. Smith
Mrs. Worcester R. Warner
Mrs. E. H. Whitlock

CELEBRATION ON JULY 4

John R. Freeman, *Chmn.*
L. P. Breckenridge
James Hartness
Henry Hess
F. G. Kretschmer

A celebration of Independence Day will be held at Homburg, v. d. h., with the coöperation of the American colony in Frankfurt.

A list of the official party follows:

SAILING ON S. S. VICTORIA LUISE

Alden, H. W.
Alden, Mrs. H. W.
Alden, Horace
Alden, Douglas
Aldrich, John G.
Aldrich, Mrs. John G.
Aldrich, John G., Jr.
Alford, L. P.
Alford, Mrs. L. P.
Allen, Miss Mabel L.
Armstrong, Miss Helen E.
Baker, Charles Whiting, Jr.
Barton, Wm. H.
Bates, Francis E.
Benner, Henry L.
Bennett, C. W.
Bennett, Mrs. C. W.
Bennett, Miss Helen
Best, J. H.
Best, W. N.
Binley, William, Jr.
Binley, Mrs. William, Jr.
Blood, Charles W. H.
Blood, Mrs. Charles W. H.
Bond, George M.
Boyer, Jos.
Bray, T. J.
Bray, Mrs. T. J.
Breckenridge, L. P.
Breckenridge, Mrs. L. P.
Briggs, Leroy E.
Brill, George M.
Brill, Mrs. George M.
Brill, G. Meredith
Brinton, Willard C.
Brooks, J. Ansel
Brown, Robert S.
Brown, Mrs. Robert S.
Brown, Wylie
Bruegel, A. T.
Bunnell, S. H.
Bunnell, Mrs. S. H.
Burleigh, P. Gray
Burleigh, Mrs. P. Gray
Bursley, J. A.
Bursley, Mrs. J. A.
Buttolph, Benj. G.
Buttolph, Mrs. Benj. G.
Carew, Clement J.
Carew, Mrs. Clement J.
Carpenter, Russell H.
Carr, C. A.
Chapman, Frank T.
Chapman, Miss Cecil L.
Christie, A. G.
Clarke, C. W. E.
Clarke, Mrs. C. W. E.
Clifford, H. E.
Coffin, Mrs. Charles H.
Coleman, R. J.
Colwell, A. W.
Connon, George W.
Connon, Mrs. George W.
Conroy, Ramon A.
Cooke, Harte
Cooke, Mrs. Harte
Dart, William C.
Davis, Francis P.
DeBaufre, Wm. L.
DeBaufre, Mrs. Wm. L.
Detrick, Jacob S.

Detrick, Mrs. Jacob S.
Dickerman, A. C.
Disque Robert C.
Doble, William A.
Doble, Mrs. Wm. A.
Doble, Jesse W.
Doble, John A.
Doble, Wm. A., Jr.
Dotterweich, A. J.
Felker, Geo. F.
Fellows, E. R.
Fellows, Mrs. E. R.
Fellows, R. M.
Fischer, Ad. K.
Fitch, William K.
Ford, F. E.
Folsom, Eugene L.
Folsom, Mrs. Eugene L.
Foucar, E. L.
Foucar, Mrs. E. L.
Freeman, John R.
Freeman, Mrs. John R.
Freeman, Clark
Freeman, Harvey L.
Freeman, John R., Jr.
Freeman, Roger M.
French, L. G.
French, Mrs. L. G.
Frost, George H.
Fuller, Arthur A.
Fuller, Mrs. Arthur A.
Gantt, H. L.
Gantt, Mrs. H. L.
Gates, Philetus W.
Gilbreth, Frank B.
Gilbreth, Mrs. Frank B.
Gillespie, Mrs. D. L.
Gillespie, Miss Mabel
Gleason, Miss Kate
Goldingham, A. H.
Goldingham, Mrs. A. H.
Goss, Chauncey P., Jr.
Goss, Mrs. Chauncey P., Jr.
Graefe, A.
Greene, Arthur M., Jr.
Greene, Mrs. Arthur M., Jr.
Guilbert, H. Moss
Guilbert, Mrs. Edmund
Haight, H. V.
Hall, James A.
Harder, Lewis F.
Hartness, James
Hartness, Mrs. James
Hersey, Mayo D.
Hess, Henry
Hess, Mrs. Henry
Hess, H. D.
Hess, Mrs. H. D.
Hess, Miss M. D.
Honsberg, August A.
Horstmann, H. J.
Horstmann, Mrs. H. J.
Jackson, A. C.
Kaup, W. J.
Kaup, Mrs. W. J.
Keller, E. E.
Keller, Mrs. E. E.
Kent, Edward R.
Kent, Robert T.
Kent, William
King, L. S.
Klein, Arthur W.
Klein, Otto H.
Knowles, Helen
Knowles, Morris
Knowles, Mrs. Morris
Kornfeld, Alfred E.
LeBlond, R. K.
Leland, H. M.
Leland, Mrs. H. M.
Leonhard, Miss Dora
Leonhard, Miss Madeline
Lodge, William
Low, Fred R.
Low, Mrs. Fred R.
Low, Giles J.
Lucas, Henry M.
Macon, W. W.
Marshall, Norman
Marshall, Mrs. Norman
Mead, Charles A.
Meier, E. D.
Meier, Miss Alice
Merriman, Mansfield
Merriman, Mrs. Mansfield
Merryweather, George E.
Miller, T. H.
Miller, Mrs. T. H.
Moore, L. C.
Moore, Miss Selma J.
Moore, Samuel L.
Moore, Mrs. Samuel L.
Morse, Arthur H.
Morse, Mrs. Fannie H.
Morse Virgil
Nelson, J. W.
Nickel, Frank F.
Nickel, Mrs. Frank F.
O'Reilly, Mrs. E. R.
O'Reilly, Miss Genevieve
Palmer, George B.
Palmer, Mrs. George B.
Pelton, E. W.
Person, Harlow S.
Pinger, George C.
Price, W. T.
Reist, H. G.
Reist, Mrs. H. G.
Rice, Calvin W.
Richards, Charles R.
Richmond, Knight C.
Riley, Joseph C.

Riley, Miss R. C.
Risteen, A. D.
Risteen, Mrs. A. D.
Roe, Joseph W.
Sadler, C. R.
Sanders, Newell
Sanders, Mrs. Newell
Schmidt, C. R.
Schmidt, F. L.
Schmidt, Mrs. F. L.
Schmitt, F. L.
Schnuck, Edward F.
deSchweinitz, P. B.
Seligman, Walter
Seubert, Arthur
Sherrerd, J. M.
Sherrerd, S. H.
Skinner, A. C.
Smith, Jesse M.
Smith, Mrs. Jesse M.
Snyder, W. E.
Snyder, Mrs. W. E.
Soverhill, H. A.
Soverhill, Mrs. H. A.
Staples, R. T.
Stebbins, Theodore
Stebbins, Mrs. Theodore
Stetson, George R.
Thompson, Hugh L.
Thompson, James R.
Thorkelson, H. J.
Thorkelson, Mrs. H. J.
Thurston, Edw. D., Jr.
Thurston, Mrs. Edw. D., Jr.
Thurston, Miss Alice M.
deTrampe, Adam
deTrampe, Countess
Trix, Jno.
Troeger, John F. R.
Troeger, Miss Theodora E.
Warner, Worcester R.
Warner, Mrs. Worcester R.
Webster, L. B.
Webster, Mrs. George
Wellman, S. Knowlton
Wellman, Julian A.
Wellman, Miss Marjorie E.
Wheeler, W. H.
Whitlock, E. H.
Whitlock, Mrs. E. H.
Wilke, Mrs. William
Wilke, Miss Charlotte
Wilkin, John T.
Wood, Walter
Young, G. A.
Young, Vincent W.

UNOFFICIAL CHILD'S TICKETS HAVE BEEN SOLD TO

Alden, Miss Madeline
Brill, Master Roland
Bunnell, Miss Elizabeth
Hess, Master H. D.
Knowles, Master Morris
Wilke, Master Henry Phillips

TO JOIN THE PARTY IN EUROPE

Adamson, Daniel
Adamson, Mrs. Daniel
Alexander, M. W.
Bates, E. P.
Bates, Mrs. E. P.
Bolles, F. G.
Brill, Elliott M.
Cole, F. J.
Cole, Mrs. F. J.
Davis, Charles Ethan
Davis, Mrs. Charles Ethan
Dean, F. W.
Dean, Mrs. F. W.
Dean, F. H.
Dean, S. W.
Fox, Mrs. Charles B.
Kretschmer, F. G.
Kretschmer, Mrs. F. G.
London, W. J. A.
London, Mrs. W. J. A.
McMyler, Miss Doris
McMyler, Miss Gertrude
McMyler, Mrs. P. T.
Marks, L. S.
Marks, Mrs. L. S.
Morgan, L. H.
Morse, Lewis K.
Robeson, A. M.
Schlachter, C. H.
Schlachter, Mrs. C. H.
Shearer, C. A.
Simon, Arthur
Simon, Mrs. Arthur
Snow, Walter B.
Snow, Miss Rachel P.
Sunstrom, K. J.
Sunstrom, Mrs. K. J.
Taylor, J. W.
Taylor, Mrs. J. W.
Thompson, David
Thompson, Mrs. David
Whiteford, James F.
Whiteford, Mrs. James F.
Whiteford, Mrs. A. W.
Wilke, William

CHANGE OF ADDRESS

Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate receipt of The Journal.

A NEW GRADE OF MEMBERSHIP AND NEW METHOD OF ELECTION

At the Baltimore meeting amendments to the Constitution providing a new grade of membership and a new method of election were adopted.

The new grade of Associate-Member now effective is intended for the engineer twenty-five years of age or over, who has risen to a responsible position in the industrial world. Engineers of this type while not qualified for the grade of member, are entitled to more recognition than is offered in the grade of Junior. The amendment reads as follows:

> An Associate-Member shall be an Engineer or a Teacher of Applied Science of twenty-five years of age or over. He must show by his experience or by his duties that he is competent to execute work in his profession.

The inauguration of this grade will tend to raise the standard of membership in the Society and permit a more accurate grading of candidates.

The old grade of Associate will henceforth apply to non-professional applicants, i.e., executive officers of industrial enterprises and others who by reason of their association with engineers are qualified to coöperate with the Society in the advancement of professional knowledge.

The Junior grade will be assigned to the young engineer who has but recently graduated from college or who has risen to a subordinate position in engineering work through his practical experience.

PROMOTIONS

All members now holding the grade of Associate or Junior and who are qualified for a higher grade under the new grading should make application in the same way as if originally applying.

NEW METHOD OF ELECTION

A method of handling applications for admission to the Society was also adopted. In accordance with this the Council has instituted a new rule which provides that the name and address of each candidate be printed in the issue of The Journal following the receipt of the application. Members will be granted 40 days in which to advise the Secretary of any objection they may have to the election of any individual.

At the expiration of the time for which an applicant is posted

the Membership Committee will meet to consider each application and make recommendations to the Council as to the grade to which candidates who receive their favorable consideration shall be assigned.

A list of the candidates together with the recommendations of the Membership Committee will then be submitted to the Council for vote by letter ballot.

Upon the closing of the ballot by the Council the Secretary will at once advise all successful applicants of their election and submit to them a statement covering initiation fee and dues for the first year. The payment of this statement shall constitute the final step in securing admission to membership in the Society.

APPLICATIONS FOR ELECTION

The Membership Committee have received applications from the following candidates. Any member objecting to the election of any of these candidates should inform the Secretary before July 15, 1913:

Alexander, Walter P., Providence, R. I.
Allen, Jean M., San Francisco, Cal.
Ash, Horace W., Boston, Mass.
Bacharach, Herman, Pittsburgh, Pa.
Baily, Thaddeus F., Alliance, O.
Ballinger, Walter F., Philadelphia, Pa.
Barnes, John S., Rockford, Ill.
Barnett, Carl P., Chicago, Ill.
Barr, James W., Cincinnati, O.
Barstz, Emil, New York
Bear, Oliver, Chicago, Ill.
Beckjord, Walter, St. Paul, Minn.
Benedict, Howard G., Hornell, N. Y.
Bergey, John E., Philadelphia, Pa.
Berrenberg, Reinold, Boston, Mass.
Billwiller, Charles J., Jr., Iquique, Chile, S. A.
Blair, Frank M., Newark, O.
Blake, Raymond F., Ann Arbor, Mich.
Block, Louis, New York
Borie, Renshaw, Stamford, Conn.
Boyer, Joseph, Detroit, Mich.
Brennan, John T., Cleveland, O.
Briggs, Harry E., Milwaukee, Wis.
Bright, Fred E., Philadelphia, Pa.
Brown, Earl W., Elyria, O.
Brown, Owsley, Springfield, Mass.
Buffington, Harry C., Minneapolis, Minn.
Burnett, Earle S., Ithaca, N. Y.
Burton, Sylvester E., Los Angeles, Cal.
Cadiry, Mozuffer, Ahmednagar, India
Caldwell, Geo. G., Chicago, Ill.
Campbell, Malcolm, Montreal, Canada
Cardona, Joseph H., Buenos Aires, Argentine Republic, S. A.
Cave, John R., New York
Church, Harold D., Detroit, Mich.
Clark, Wm. E., Muskegon, Mich.
Connor, Herbert, San Francisco, Cal.
Conroy, Thomas M., Lima, O.
Costerian, Marc R., Los Angeles, Cal.
Coutant, Jay G., Watervliet, N. Y.
De Andrade, Joaquim G., Ma aro, Brazil, S.A.
Donaldson, Harold R., Schenectady, N. Y.
Dugan, Claude M., Jr., Louisville, Ky.
Dye, Ira W., Culebra, C. Z.
Dykstra, John E., Rock Falls, Ill.
Early, John Wesley, Denver, Colo.
Eckert, Arthur C., St. Louis, Mo.
Eddison, Wm. B., New York, N. Y.
Edema, Bertus J., Midland, Pa.
Edgerton, Lloyd B., Upland, Pa.
Eiselt, Emil, Baltimore, Md.
Errunza, Jamnadas C., Baroda, India
Fairchild, Fred P., San Diego, Cal.
Fales, Henry H., Boston, Mass.
Farkell, Geo. C., Elyria, O.
Farley, Ernst W., Richmond, Va.
Fraim, Samuel R., Lancaster, Pa.
Freeman, Roger M., Boston, Mass.
Freund, Walter F. W., Ann Arbor, Mich.
Frink, Francis G., Seattle, Wash.
Frost, Frank G., Houston, Texas
Gardner, Wm. M., Memphis, Tenn.
Godfrey, Foskett H., Tacoma, Wash.
Goebler, Chas., Poughkeepsie, N. Y.
Grunwell, Paul C., Louisville, Ky.
Gunther, E., Vancouver, B. C.
Gupta, Birendra Chandra, Srinagar, Kashmir, India

Hall, Edwin J. C., Yonkers, N. Y.
Hall, Wm. G., Honolulu, Hawaii
Harrington, Wellesley C., Ithaca, N. Y.
Hasberg, Wm. M., Chicago, Ill.
Hays, John C., Visalia, Cal.
Hawkins, Geo. W., Tucson, Ariz.
Hawley, Wm. A., Indianapolis, Ind.
Hepburn, Harry M., Honolulu, T. H.
Hinckley, Frank C., Boston, Mass.
Holmes, Frederick S., New York, N. Y.
Homi, E., Sakchi, India
Howard, Ernest E., Kansas City, Mo.
Howarth, Jacob M., Chicago, Ill.
Howell, Horace L., Niagara Falls, Ont., Can.
Huffman, John C., Riverside, Cal.
Hufsmith, Clifford L., Port Arthur, Texas
Hults, Eugene A., Chicago, Ill.
Hunt, Paul B., Milwaukee, Wis.
Huntington, Clarence W., New York, N. Y.
Insley, Wm. H., Indianapolis, Ind.
Isenbero, Hans O. C., Wilkes-Barre, Pa.
Jaeger, Max, Mt. Vernon, N. Y.
Johann, Charles S., New York, N. Y.
Kalbach, Samuel E., Reading, Pa.
Kearney, Wm. J., Oglesby, Ill.
Kelley, Fredk. H., Franklin, N. H.
Kennedy, James E., Hakalau, Hawaii
Keown, Robert McA., Madison, Wis.
Kessing, Albert F., Porterville, Cal.
Kineade, Elmer C., Beaumont, Tex.
Kipp, Theo., Jr., Moose Jaw, Canada
Knerr, Dan G., Springfield, O.
Knoebel, Carl B., Sinton, Texas.
Kopke, Ernst, Honolulu, T. H.
Kramer, Frank E., Mansfield, O.
Lynch, Michael A., Washington, D. C.
Lyon, Clifford W., Mildred, Kan.
McDowell, Edward C., Hamilton, Canada
Makutchan, Ralph W., Hobart, Ind.
Martensis, John Van S., Minneapolis, Minn.
Mead, Charles A., Upper Montclair, N. J.
Mehta, Darabsha B., Bombay, India
Meredith, Wynn, San Francisco, Cal.
Messner, Manfred, New York, N. Y.
Miller, John A., Nazareth, Pa.
Miller, John V., Silver Lake, N. J.
Mitchell, J. Hanson, Richmond, Va.
Moeller, Wm., Jr., Independence, Kans.
Moore, Edmund B., Springfield, Vt.
Moran, Daniel J., Ancon, C. Z.
Morrill, Guy L., Ann Arbor, Mich.
Morton, John W., Brooklyn, N. Y.
Mueller, Herman F., Minneapolis, Minn.
Munson, Chas. C., New York, N. Y.
Murphy, Ralph, Syracuse, N. Y.
Nagy, Bela, E. Cleveland, O.
Nathan, T. U. S., Gulbargar, Hyderabad, India
New, Wm. E., Kansas City, Mo.
Nichols, Fred C., Balboa, C. Z.
Ohren, George A., Vancouver, B. C.
Otto, Fredk. A., St. Paul, Minn.
Patel, Chunilal N., Baroda, India
Pearce, Ernest L., Marquette, Mich.
Pender, Benjamin D., Washington, D. C.
Peterson, Emil A., Appleton, Wis.
Philipp, Paul C., New York, N. Y.
Pierce, Burton B., Concrete, Wash.
Pinch, H. H., Transcona, Manitoba, Can.
Plant, Oliver W., Detroit, Mich.
Platt, Louis J., Ensenada, P. R.
Powers, James, New York, N. Y.
Purchas, Arthur W., Oilfields, Cal.
Putnam, Frederic W., Durham, N. H.
Redlein, Geo. L., Buffalo, N. Y.
Rhodes, Geo. H., Akron, O.
Roberts, Eugene D., Tacoma, Wash.
Robinson, Chas. G., Pittsburgh, Pa.
Robinson, Walter P., Toronto, Can.
Rorabeck, Claude, Dayton, O.
Rose, Fred Wayland, Minneapolis, Minn.
Rosencrants, Fay H., Corvallis, Ore.
Rotherham, George G., Troy, N. Y.
Rowntree, Frank L., Meriden, Conn.
Schell, Erwin H., Providence, R. I.
Scheurmann, Walter P., Dayton, O.
Scott, J. Murray, Port Augusta, Australia
Scott, Wirt S., Columbus, O.
Serrano, Luis R., Santiago, Chile
Simeon, Charles J., Worcester, Mass.
Sitaramachar, Bachahalli, Mysore, S. India
Smith, Frederick Crocker, Port Arthur, Tex.
Smith, Jas. A., Schenectady, N. Y.
Souba, Wm. H., Ft. William, Can.
Spice, Charles G., Detroit, Mich.
Sprague, Benjamin O., Adeline, La.
Staines, Albert G., Wilkes-Barre, Pa.
Stenbol, Carl, Copper Cliff, Ont., Can.
Stickney, Charles A., St. Paul, Minn.
Strong, Albert Wm., Minneapolis, Minn.
Struckmann, Edwin, Des Moines, Iowa
Sweetzer, Wm. J., Cleveland, O.
Taylor, Donald F., E. Pittsburgh, Pa.
Taylor, Stevenson P., New York, N. Y.
Thayer, Wm. C., Dayton, O.
Todd, Wm. J., Edmonton, Can.
Valtier, Franz v., Chicago, Ill.
Van Haerst, John C., So. Bethlehem, Pa.
Vincent, Gilbert I., Des Moines, Ia.
von Rottweiler, George, Waterloo, Ia.
Walden, Albert E., Baltimore, Md.
Ward, Clarence E., Cleveland, O.
Whitacre, Robert B., St. Paul, Minn.
White, J. Wm., Jr., San Francisco, Cal.
Whitney, Chas. S., New York, N. Y.
Wilson, H. Howell, Altoona, Pa.
Wood, Ernest H., Wilmington, Del.
Wood, Wm. R., St. Paul, Minn.
Worthen, Charles B., Trenton, N. J.
Zimmerman, Peter C., Yamhill, Ore.

PROMOTION FROM JUNIOR

Breslove, Joseph, Pittsburgh, Pa.
Chess, Harvey B., Jr., Pittsburgh, Pa.
Church, Elihu C., New York
Core, W. Wallace, Newark, N. J.
De Baufre, Wm. L., Annapolis, Md.
Fisher, Elbert C., Saginaw, Mich.
Forgy, John E., Wilmington, Del.
Glasgow, Carr L., Montreal, Can.
Greene, Ernest Woodruff, Nutley, N. J.
Mott, Abram C., Jr., Philadelphia, Pa.
Randall, John A., Brooklyn, N. Y.
Rupp, Manning E., Encoyd, Pa.
Sprau, Wm. C., Chicago, Ill.
Taylor, Harvey B., Philadelphia, Pa.
Wheeler, Earl, Washington, D. C.

PROMOTION FROM ASSOCIATE

Douglas, Courtney C., Chicago, Ill.
Lockett, Kenneth, Chicago, Ill
Vandemoer, John, Chihuahua, Mexico

SUMMARY

New applications	186
Promotion from Junior	15
Promotion from Associate	3
Total	204

CURRENT AFFAIRS OF THE SOCIETY

Among the bequests of the will of the late Admiral Geo. F. Melville, Past-President and Honorary Member of the Society, was one of one thousand dollars to the Society, to be devoted to the annual award of a gold medal, known as the Melville Prize Medal, for original work.

MILWAUKEE SECTION

The members of the Society in Milwaukee and its vicinity have organized a local section and a committee, consisting of Fred. H. Dorner, Chairman: Arthur Simon, E. P. Worden, M. A. Beck, and Henry Weickel, has been appointed. It is proposed to hold not less than two meetings a year, and to coöperate in professional meetings and other matters with the Milwaukee Engineers Society and the Milwaukee section of the American Institute of Electrical Engineers.

NATIONAL DRAINAGE CONGRESS

The Society was represented at the National Drainage Congress in St. Louis, April 10-12, 1913, by John Hunter, Honorary Vice-President, and a very complete report of its proceedings was recently rendered to the Council. In view of the great floods in the middle West, the congress was the most important of the three thus far held, and much attention was drawn to it from all parts of the country. Its three hundred or more delegates included prominent engineers, doctors, public officials and

private citizens from nearly every state in the union. Resolutions were adopted calling on President Wilson and Congress to establish a department of public works, to have general charge of all conservation and reclamation work, and the formation of a National Malarial Congress was also endorsed to have special charge of the stamping out of malaria.

ELLIOTT CRESSON MEDAL AWARDED TO DR. STEINMETZ

One of the Elliott Cresson Medals was awarded this year by the Franklin Institute to Dr. Chas. P. Steinmetz, Mem.Am.Soc. M.E., who delivered before the meeting called for the purpose an address on Some Electrical Problems Awaiting Solution.

CALVIN W. RICE, *Secretary.*

RESOLUTIONS ON THE DEATH OF JOHN FRITZ

At a recent meeting of the Board of Directors of the John Fritz Medal Fund Corporation, established to perpetuate the memory of Mr. Fritz, and upon which the Society is represented by four members, as are also the American Society of Civil Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers, the following resolutions were adopted:

The Board of Directors of the John Fritz Medal Fund Corporation, learning with sorrow of the death of Mr. John Fritz at his home in South Bethlehem, Pennsylvania, on February 13th, 1913, in the ninety-first year of his age, desires to place upon its records this minute, upon the completion of his long and useful life of effective service to his profession and his country.

In 1902, when Mr. Fritz was approaching his eightieth birthday, his friends and admirers planned to give a dinner at which he should be the guest of honor. A dinner, however, was felt by many to be inadequate to commemorate so great a man, and to signalize the indebtedness of the profession of engineering for such a life so lived. A dinner, however, is soon forgotten and leaves no permanent record. Out of this thought grew the idea of creating a fund, by gift from the many who could attend and from the many more who could not be so assembled, the income from which should be used in honor of Mr. Fritz, to recognize and reward achievements in engineering similar to those which had made his life so valuable to the profession and to the world. The result was a substantial subscription from the members of the four great engineering societies, and from other friends and professional associates of Mr. Fritz, and the creation of an incorporated body, to act as Trustees of the fund, and the judges who should award a medal for notable scientific or industrial achievement.

The directors of the corporation founded in April 1903, to execute this trust, do not feel that they are called upon on this occasion to make any

extended reference to the professional achievements of Mr. Fritz, or to his fine character and the charm of his personality. This has been done elsewhere and by competent hands. But it will be proper to refer to the influence which the achievements and the character of the man whose name it bore has always had in the award of the John Fritz Medal. The recipient of it must have done some notable thing such as would have commended itself to the clear-headed judgment and the kindly approval, of the man in whose honor the Board was created to act. It is the wish and the ambition of the Board of Award that it shall ever maintain the standard set by the life and achievements of Mr. Fritz in the men and their achievements, to whom the John Fritz Medal is awarded.

The Board feels that the ordinary phrases of corporate action would be inappropriate upon the termination of such a splendid life by the summons to yet higher service, especially when such Board exists for the specific purpose of perpetuating and making influential the noble spirit and high ideals of such a life by rewarding achievement in its field.

What it may properly do is to express thankfulness that the life was spared so long, and to record its pledge that this Board will ever strive so to carry out its purpose that the name and the life of John Fritz may be powers for good through the years to come and in the fields of Applied Science in which he made himself so eminent, and that it shall thus help to keep bright the luster of that name.

Resolved, That this minute be spread in full upon the records of the John Fritz Medal Fund Corporation, and that copies of it be sent to the secretaries of the four engineering societies represented on that body for such publication as they may deem proper.

SIR WILLIAM HENRY WHITE

The distinguished Naval Architect and Honorary Member of The American Society of Mechanical Engineers, Sir William Henry White, passed away on the 27th of February, 1913, bearing the profound respect of the engineering profession throughout the world.

He entered the service of his country as an apprentice, and by assiduous application and inborn ability rose to the highest rank in naval construction in the British Admiralty.

Born in 1845, he entered the British Dockyard at Devenport as an apprentice at the age of fourteen. While working in the shops he attended the dockyard school and won the Admiralty Scholarship in 1863. During the year 1864 the Royal School of Naval Architects was established at South Kensington. Young White took first place in the first entrance examinations of that school, maintained first place, and was graduated first with the honorary degree of Fellow in 1867. He immediately entered the British Admiralty and remained there until 1902 when he was obliged to resign by reason of failing health.

In 1873 he became Secretary of the Council of Construction of the Navy under the Presidency of Sir Nathaniel Barnaby. He rapidly rose to the rank of Chief Constructor when in 1881 he resigned to take charge of the shipyard newly organized by Sir William Armstrong at Elswick, England. Here he designed many warships for foreign governments, including two cruisers for the United States. Upon the resignation of Sir Nathaniel Barnaby in 1885, and upon the recommendation of his former chief, he was recalled to the Admiralty as Director of Naval Construction.

At this time the question of largely expanding and rebuilding the British Navy was under consideration, and he found himself in charge of the engineering of this great work. Continuously for seventeen years, and until his health was broken by overwork in 1902, he labored on and revolutionized the navy. During that period he designed 245 warships, including 43 battleships, 202

cruisers of different classes, and many torpedo boats and destroyers, which were built at a cost exceeding $500,000,000. The largest warship previous to this time was 340 feet long and 10,600 tons displacement. His ships of the King Edward VII class were 425 feet long and 16,350 tons displacement. The speed of armored cruisers during his régime increased from 17 to 24.5 knots, the length from 315 to 500 feet, and the displacement from 8400 to 14,000 tons. His designs were so scientifically and accurately worked out that in no case did the actual ships exceed in draft or displacement the estimates of the design. High propulsive efficiency was always realized, and in no instance did a ship fail to attain the required speed.

Mr. White was rewarded for his notable achievements by a C.B. in 1891, by a K.C.B. in 1895, and by a special grant by Parliament in recognition of " exceptional services to the Navy."

After his retirement from the Admiralty in 1902, he regained his health and was enabled to take up other important engineering work. He was one of the Cunard Commission that settled the question of propelling the Lusitania and Mauretania by steam turbines, and was a director of the firm of builders of the latter. He also designed steamers with geared turbines for service in India.

Sir William was distinguished as an author. His Manual of Naval Architecture is a classic, and of no less value is his Treatise on Shipbuilding. His many papers on many different engineering subjects presented before many engineering and scientific societies all contributed to his renown.

He was greatly interested in the education of the engineer and did much to elevate the standards of technical schools. His lectures in the Royal School of Naval Architecture from 1870 to 1881 resulted in the accession to the navy and private shipbuilding works of a new and much needed class of designers.

He was honored by many societies by election to offices of distinction. He was Honorary Vice-President of the Institution of Naval Architects; Fellow of the Royal Society; Honorary Member of The American Society of Mechanical Engineers, of the American Society of Civil Engineers and of the American Society of Marine Engineers and Naval Architects. He has been President of the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Archi-

tects, the Institution of Marine Engineers, the Institute of Metals, and was President-Designate of the British Association.

He received the honorary degrees of D.Sc. from Cambridge University and Durham, England, and from Columbia University, New York City, also of D.Eng. from Sheffield and LL.D. from Glasgow. In 1911 he was awarded the John Fritz Medal for "notable achievements in naval architecture."

Sir William White's personal character was known of all engineers. He was above all, straight and manly, a gentleman ready to see the good in others, yet vigorous and steadfast in his own convictions. He was intolerant of shams and of opinions based on self-interest, but always ready to encourage the young engineer who was true to his profession.

Services were held simultaneously at Holy Trinity Church, Roehampton, and at St. Margaret's, Westminster, London.

The notable engineering societies and many other scientific and other organizations were represented at the services, including this Society. The interment is in the cemetery at Putney, London.

His wife, one daughter, and three sons, officers in the British Navy, remain to mourn his loss. J. M. S.

TEST OF A HYDRAULIC BUFFER

By Carl Schwartz

ABSTRACT OF PAPER

The paper discusses the performance of a hydraulic buffer for railroad terminal stations and the means used for the test. The results show the energy absorbed by the buffer under various conditions of train speed and weight and indicate how a buffer should be constructed to be least harmful to the train equipment.

TEST OF A HYDRAULIC BUFFER

By Carl Schwartz, New York

Member of the Society

The object of this paper is to describe the methods used to determine the performance of an experimental hydraulic buffer for railroad terminal stations and the results obtained; also to illustrate the conditions imposed upon equipment when striking the buffer. It is not intended to enter into the question of design of hydraulic buffers nor to discuss the relative advantages and disadvantages of various means to protect the ends of the railroad tracks against overrunning of trains.

2 The office of a buffer being to bring a locomotive or a train to a standstill when, either by accident or carelessness, it overruns its stopping point, an ideal buffer should be constructed so that during the period of its travel the pressure exerted against the train will be uniform. The buffer will thus absorb the greatest amount of work possible with the smallest maximum resistance against the train, and if it fulfils this condition the reaction will be least harmful to the equipment. In how far the buffer installed in its present form approaches ideal conditions will be shown by the records.

3 The buffer tested consists of a cast-steel cylinder of 22 in. internal diameter, or 380 sq. in. area, and 11 ft. working length. The cylinder is grooved to permit a variable quantity of water to pass by the piston, the amount depending upon the position of the piston, and is largest with the piston drawn out in position to receive a train.

4 The piston proper is attached to a steel ram 10 in. in diameter, extending through a stuffing box, and carrying at its extreme end a head of cast steel with a wooden protection board accurately aligned with the locomotive buffer. The buffer cylinder is connected to city water service, the pressure of which is sufficient to drive the

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piston out, and the water discharged during the stroke is disposed of to the sewer.

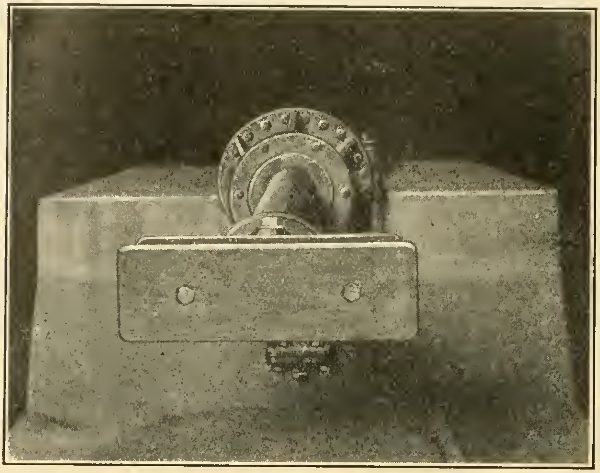

Fig. 1 Front View of Buffer

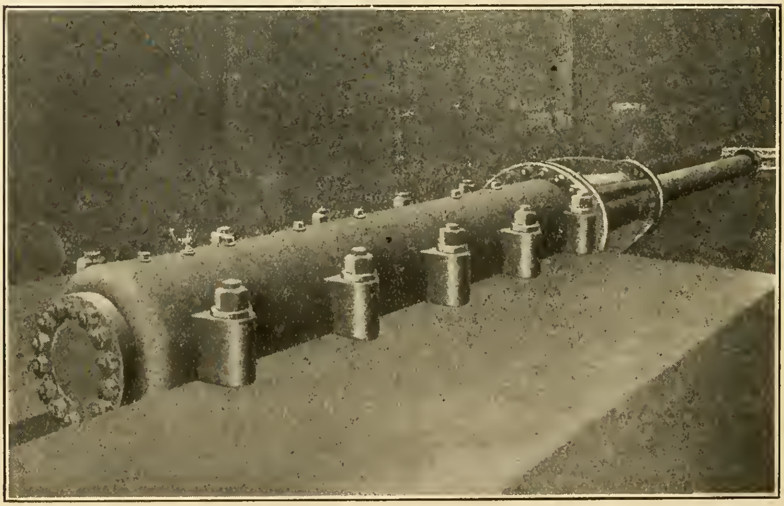

Fig. 2 Side View of Buffer

5 The buffer is installed rigidly upon and partly imbedded in a block of concrete 20 ft. long, 12 ft. wide and $10\frac{1}{2}$ ft. deep, a total of 90 cubic yards. It is held on each side by five bolts of $2\frac{3}{8}$ in. in diam-

eter extending through the foundation into bed rock by a length varying from 6 ft. in the rear to 13 ft. in the front. The weight of the structure is approximately 390,000 lb. The buffer is illustrated in Figs. 1 and 2.

6 The information required to determine the performance under different working conditions outside of the weight of the train is principally:

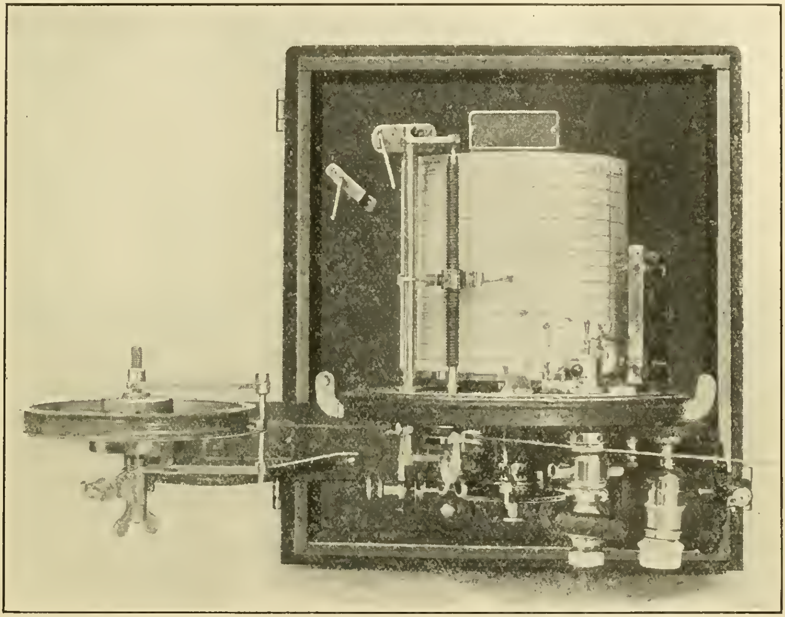

FIG. 3 RECORDING INSTRUMENT

a Speed of train striking
b Pressure performance in cylinder during stroke
c Travel of buffer piston.

7 The time of performance being exceedingly short, it was necessary to record the readings automatically, and a special instrument for this purpose was built by an instrument manufacturer on specifications prepared by the writer. See Fig. 3. This instrument consists of the following parts or mechanisms:

Recording Cylinder. A vertical cylinder bearing a recording chart is driven through a worm gear by a small electric motor and can be adjusted by means of a speed regulator to make one revolution in 12 seconds. The circumfer-

ence of the cylinder being 24 in., 2 in. corresponds to a period of 1 second.

Train-Speed Recorder consists of an electromagnet moving a pen vertically over the chart in five successive steps. Five contacts were placed on the track 25 ft. apart in front of the buffer, and these contacts were made and broken by the train and actuated the speed recorder.

Pressure Recorder is constructed like a steam-engine indicator and by the change of pistons and springs can be used for recording pressures from 0 to 2400 lb. per sq. in. Connection to the rear of the buffer cylinder was made by a small copper tube.

Piston-Travel Recorder consists of a worm screw carrying a pen vertically over the chart and is actuated by a cord running from a wheel on a winding spring over a wheel on the worm screw to the head of the buffer.

8 The pressure recorder and piston-travel recorder, operating above each other simultaneously, give the position of the buffer piston and the hydraulic pressure prevailing at any position of the piston.

9 A few preliminary trials were made to adjust the testing apparatus, ascertain approximately the performance of the buffer, and familiarize the engineers making the tests with the apparatus. The tests finally recorded were made on March 8 and 9, 1913, with the equipment and train speeds as given in Table 1. The travel of the buffer piston and the maximum pressure in the buffer cylinder as recorded are also given.

10 From the readings obtained the curves in Figs. 4, 5, 6, 7 and 8 were plotted. In Fig. 4 the highest speed tested was 8.10 miles per hour, at which the maximum cylinder pressure was found to be 1135 lb. per sq. in., corresponding to a total resistance of 431,000 lb., 18,000 lb. of which was balanced by back pressure, leaving 413,000 lb. effective to stop the train. All readings applying to the light locomotive fall almost exactly on the curve and the curve has been extended to show the probable pressure at higher speeds. The readings applying to trains do not coincide as closely with the curve for the reason that the car couplings and the swinging of the cars back and forth had an erratic influence.

11 In Fig. 5 curves *a, b, c* and *d* apply to locomotives and trains of 100 tons, 228 tons, 343 tons and 458 tons respectively and show corresponding maximum piston travels of between 3 and 7 ft. It

will be seen that above $5\frac{1}{2}$ and 6 miles per hour the speed of the train has practically no influence upon the travel of the piston; also below $5\frac{1}{2}$ miles per hour the difference in piston travel due to train speed is relatively small.

12 Figs. 4 and 5 illustrate the fact that the impact and pressure against the train depend largely on its speed and that the piston travel is principally a function of the train weight.

TABLE 1 RECORD OF TESTS

Test No.	Equipment	Weight, Tons	Speed Striking, M.P.H.	Piston Travel, Ft.	Max. Cylinder Pressure, Lb. per Sq. In.
4*	Locomotive	100	4.45	2.69	460
5	Locomotive	100	5.00	2 65	525
8	Locomotive	100	5.30	2.70	585
10	Locomotive	100	6.40	2.90	730
1†	Locomotive	100	7.21	3.00	940
2	Locomotive	100	8.10	3.00	1135
3	Locomotive	100	7.12	3.00	940
4	Locomotive	100	7.70	3.00	1030
5	Locomotive, 2 cars	228	4.42	4.25	490
6	Locomotive, 2 cars	228	4.48	4.25	460
7	Locomotive, 2 cars	228	5.37	4.30	690
8	Locomotive, 2 cars	228	6.50	4.50	790
9	Locomotive, 4 cars	343	3.15	5.25	230
10	Locomotive, 4 cars	343	2.90	5.20	200
11	Locomotive, 4 cars	343	4.80	5.75	515
12	Locomotive, 4 cars	343	5.76	5.85	790
13	Locomotive, 6 cars	458	4.50	6.56	460
14	Locomotive, 6 cars	458	5.92	6.50	820

* The first four tests, Nos. 4, 5, 8, 10, were made March 8, 1913.
† Tests 1-14 were made March 9, 1913.

13 The curve in Fig. 6 was derived from the preceding and is intended to determine the maximum capacity of the buffer. The highest train weight tested was 458 tons and the extension of the curve shows that a train weight of 1000 tons will drive the buffer piston probably between 10 and 11 ft., or about the total travel for which the buffer is constructed.

14 Fig. 7 covers test No. 1 on March 9 and the curves show the complete performance with a 100-ton electric locomotive running light, as follows:

a Speed of the locomotive approaching and during the stroke
b Pressure during the stroke
c Horsepower absorbed.

The area covered by the horsepower curve gives the total energy absorbed by the buffer as 368,000 ft-lb., to which should be added

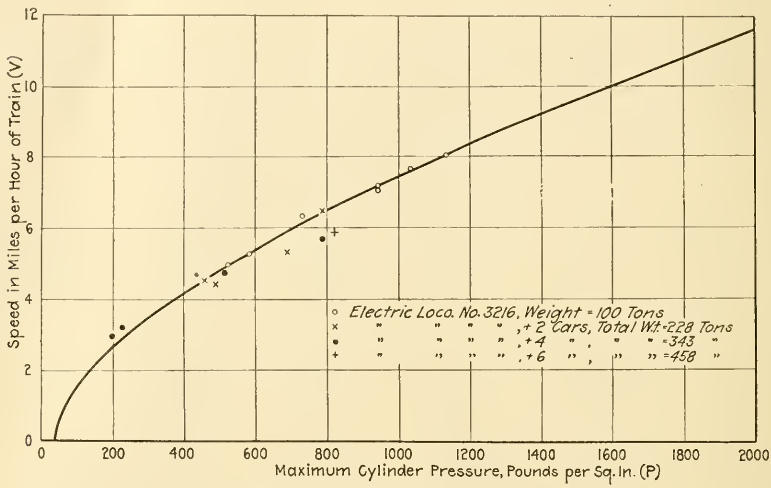

Fig. 4 Pressure in Buffer and Train Speed

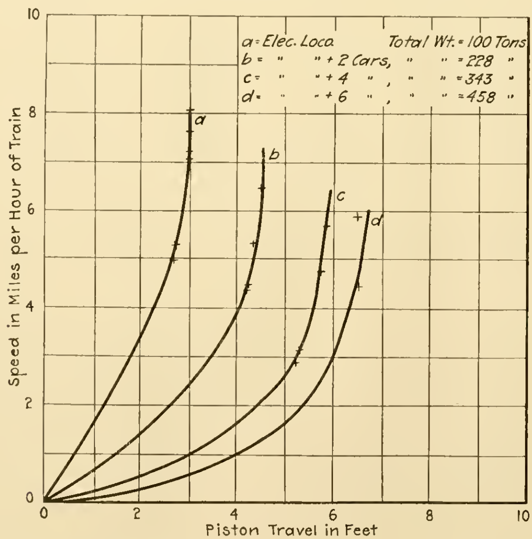

Fig. 5 Weight and Speed of Train and Piston Travel of Buffer

the resistance of the locomotive, calculated at 2400 ft-lb., to obtain a total resistance of 370,400 ft-lb. The energy in the locomotive

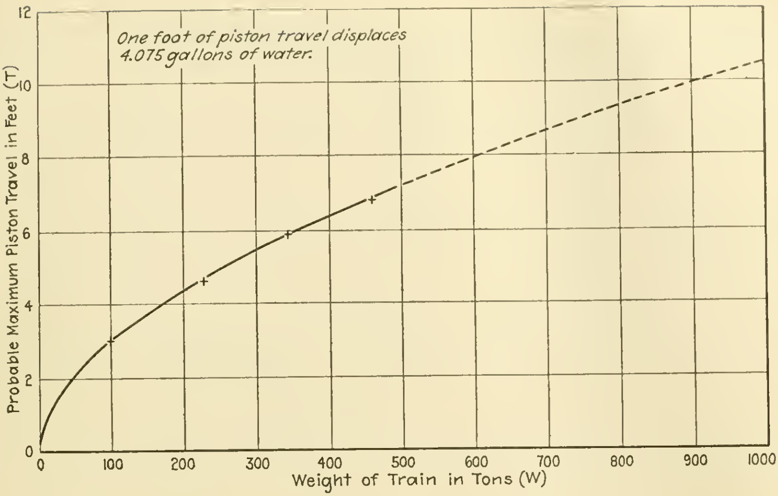

FIG. 6 WEIGHT OF TRAIN AND MAXIMUM PISTON TRAVEL OF BUFFER

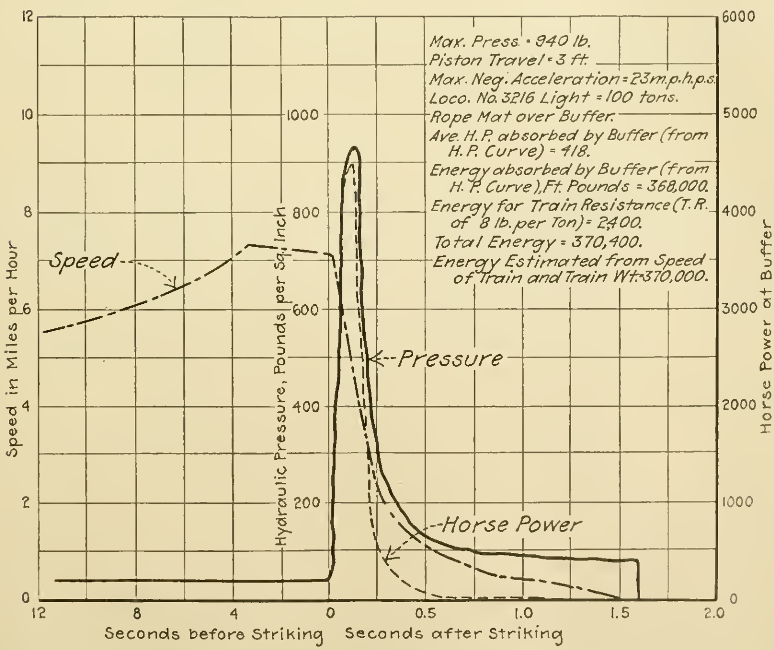

FIG. 7 TOTAL PERFORMANCE—TEST NO. 1, MARCH 9, 1913

based upon speed and train weights has been approximately calculated at 370,000 ft-lb., which coincides closely with the resistance recorded. The pressure curve starts with the city water pressure of about 40 pounds and was found after the stroke to be about 80 pounds, the difference being due to resistance in the discharge valve.

15 Fig. 8 covers test No. 11 and the curves show the complete performance with a train consisting of a 100-ton locomotive and four pullman cars, the total weight of the train being 343 tons. In comparing this curve with Fig. 7, the following should be noted:

16 The maximum pressure is only about 500 lb. instead of 900 lb. because the speed of the train was only 4.8 miles per hour instead of 7.2 miles per hour. The peaks in the pressure curve are probably due to the locomotive and cars striking separately about as follows: Locomotive buffer 300 lb., locomotive body 500 lb., first car 390 lb., second car 300 lb., third car 420 lb. and fourth car 360 lb.; but evidently the train was drawn together and pulled apart, which makes the performance somewhat irregular. Comparison between the energy absorbed by the buffer and the energy in the moving train shows a discrepancy of about 128,000 ft-lb., or roughly, 25 per cent, which can be accounted for as energy absorbed in the train by its parts swinging back and forth during the impact.

17 Other tests were calculated like the results given in Figs. 7 and 8 and show similar and consistent performance.

CONCLUSIONS

18 Referring to Fig. 7, it will be seen that the bulk of the energy is absorbed during the first $\frac{1}{4}$ second of the stroke; the impact was considerable after striking, the pressure falling off immediately after exceeding the maximum. Fig. 8 would show similar results had the speed of the train been higher than 4.8 miles per hour.

19 It was demonstrated during the tests that the buffer was sufficiently effective to prevent damage to the locomotive or equipment though the speeds were at times relatively high.

20 It is evident that the impact can be made smaller by distributing the pressure uniformly over the period of the stroke. To do this the leakage in the buffer should be increased at the beginning of the stroke to reduce the initial peak in the pressure curve at speeds exceeding, say 4 miles per hour. This will increase the travel of the piston for a given train weight and reduce the capacity of the buffer to some extent. If the leakage is brought into definite relation to the pressure curve the buffer should offer a uniform resistance against the train.

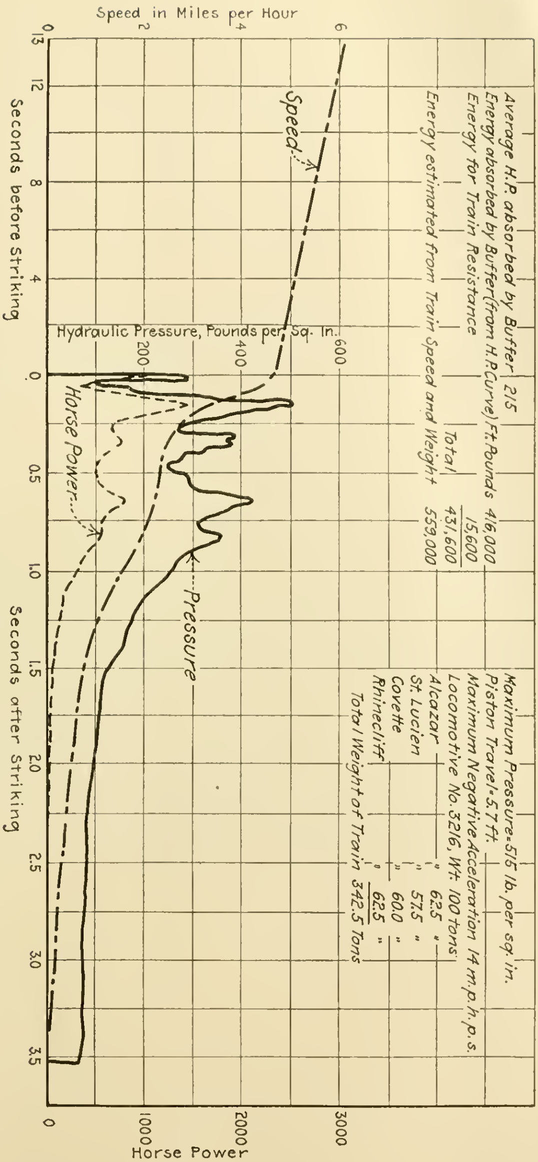

FIG. 8 TOTAL PERFORMANCE—TEST NO. 2, MARCH 9, 1913

21 In how far these conditions can be approached in practice is a matter of investigation and the writer hopes that this contribution may be of assistance in understanding the conditions to be fulfilled.

DEBARMENT OF CITY CONFLAGRATIONS

By Albert Blauvelt

ABSTRACT OF PAPER

The intent of this paper is to eliminate through facts and experience in hand those things which cannot debar city conflagrations, and deduce those things which can combine for debarment.

The paper explains the two ways in which conflagrations begin, and reviews various safeguards and methods of fire protection which singly cannot debar conflagrations. Of these the establishment of fire limits, an ample water supply and adequate fire department as already developed cope with all fires except the true conflagration type of hot blast.

Two plans for debarment are discussed: one by deflection by means of the walls of buildings constructed of fire-retardant materials and having wire-glass windows; and the other by absorption by means of sprinklered buildings.

The advantages and disadvantages of each are given in detail, together with a summary of values, costs and gains attending the equipment recommended in the paper.

DEBARMENT OF CITY CONFLAGRATIONS

By Albert Blauvelt, Chicago, Ill.

Member of the Society

Every conflagration must necessarily begin in one of two ways, or with a combination of both, Chicago in 1871 and Baltimore in 1904 being examples of the two types.

2 The Chicago fire started outside of the congested district, developed into hot-blast form, and swept through and beyond the congested district, and burned out for lack of fuel.

3 On the other hand, the Baltimore fire started in the heart of the city and ramified more swiftly than the firemen could operate; then took the hot blast form and burned out for lack of fuel.

4 Such great conflagrations arouse interest in plans (*a*) to debar the present ease of spread of fire inside the costly districts; and (*b*) to debar any deep inroad of fires which may get away from firemen in the outskirts, which admittedly are too spread out and cheap to be adequately protected.

5 The first problem would necessarily be solved by a solution of the second because the latter involves the more severe type of fire, a moving fire with a trail of burning embers making fire department work impossible from the rear. Such a fire has a central hot blast longer than any high pressure or other hose stream and a brisk breeze blowing on the hot blast in a relatively horizontal position compels abandonment of the advancing front.

6 Such a hot blast has never been stopped by firemen while the wind held, but has, however, been checked and deflected upward by barriers consisting of two or more fire walls or their equivalent, with a free air space between, as in the case of various moderate, yet true hot-blast fires which have been stopped by an alley fully shuttered on each side.

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7 It has also been possible to absorb the hot-blast attack of such fires by a very deep and fixed mass of spray in the form of sprinklered buildings. The Boston fire of 1893 was largely absorbed by an exceptionally good water supply in such form, and a somewhat similar experience was had at Toronto in 1904.

8 These successful experiences in checking hot-blast fires by deflecting the flame or by absorbing it in a mass of spray have been but little appreciated and instead of acting upon the lessons which they teach, our cities today have a collection of safeguards, part of which lend themselves to the debarment of conflagrations and part of which do not.

SAFEGUARDS WHICH SINGLY CANNOT DEBAR CONFLAGRATIONS

9 The recognized and partly recognized safeguards against fire, but no one of which alone can debar conflagrations, are twelve in number, viz., fire prevention; the fire limits; the water supply; the fire department; the high-pressure fire system; the uniform hose thread; the water curtain; the so-called fireproof building; the horizontally divided building; the protected window; the sprinklered building; and the piped building.

10 Dynamite, private hose, steam jets, carbonic gas systems, and fire walls separate from buildings are not listed because they are not recognized by fire chiefs for valid reasons.

11 *Fire Prevention.* This subject, in an engineering sense, is limited to reducing the frequency of fires. The preponderance of disasters from trivial, unknown or unguessable causes appears to forbid hope of debarment of conflagration through fire prevention. Besides this, a half century of experience with our cities shows that the skill and effort directed to prevent fires from becoming disasters has been successful within 0.00003 of the total fires. This 0.00003 is what has hurt, and appears to be the only considerable task of correction remaining for the engineer.

12 *The Fire Limits.* This is an expression indicating a central territory at least, within which frame construction or shingle roofs are prohibited and where perhaps certain construction details are enforced, especially for large area buildings. The elimination of frame buildings and shingles is an essential part of any plan to debar conflagration.

13 *The Water Supply.* This paper argues that the water supply is indispensable and also in the main is adequate.

14 *The Fire Department.* While no fire department has ever been able to put water on the front or rear of any hot-blast type of conflagration, nevertheless, the fire departments at time of conflagration have been of gigantic value in keeping the fire from spreading across the wind, in extinguishing brands thrown far ahead, etc. Were this not so, all past conflagrations would have assumed the proportions of that in helpless San Francisco. The fire department, therefore, is indispensable (because also of its signal and salvage aids), and this paper argues to increase its opportunity, but not its cost and size.

15 *The High-Pressure System.* Those cities which are equipped with costly high-pressure systems enjoy an advertisement which does not appear to be shared nor courted by the group of valley cities with reservoirs on high bluffs or hills. The latter afford a high-pressure service for the whole, not parts of such cities and higher pressure and greater volume relative to their buildings than by other means. Powerful high-pressure hydrant systems have also long existed in a goodly number of cities in the form of special inland hydrant lines operated by fire boats.

16 A high-pressure system is a means for saving siamese work, and more easily develops long and large hose streams, but there is nothing about it to enable firemen to use such hose streams either in advance, or in the rear of, a hot-blast conflagration, nor is a high-pressure system especially flexible to check the ramification of fire as at Baltimore in 1904.

17 In general it is a matter of choice between high-pressure hydrants and portable engines. Both plans are good and both plans work much alike as to results.

18 *The Uniform Hose Thread.* Since the fire department is indispensable, ability to double up departments is obviously wise and Mr. Griswold's long labors and separate paper on this subject are exactly in point.

19 *The Water Curtain.* It is fair to say that a water curtain has successfully held off some heavy fires, but never a developed hot-blast conflagration. The fatal weakness of the water curtain is that it is blown away or at least scattered by the brisk breeze which necessarily accompanies a hot-blast conflagration. The depth of the spray is also far too shallow.

20 The water curtain, as shown by fire record results, is a valuable safeguard for moderate exposure fires, or even for fairly

severe exposure when favored by quiet air, but fails in severe tests.

21 *The Fireproof Building.* The typical, so-called "fireproof" building, having merely incombustible floors, roof and walls, cannot debar a conflagration (because of its unprotected windows and large volume of contents) any more than can an ordinary brick building with a good roof.

22 A hot-blast conflagration moves laterally, and a "fireproof" building in its path, as evidenced at Baltimore, is merely a crate which holds up the fuel contents in position for free burning and augments the general hot blast. Such buildings have been somewhat successful with fires in small rooms containing, say 1000 lb. of fuel.

23 It is contents, not buildings, which make the bulk of property loss; contents, not buildings, which are hazardous; contents which burn buildings in most cases, and the low fire cost statistics which purport to compare European engineering with ours include cities which show a low fire cost from sheer poverty of contents.

24 Repeated experience shows that no building can withstand the heat due to burning any large quantity of contents or even very moderate contents if in a large rotunda, half floor office or like large area, constituting in effect a calorific bomb or retort. The writer submits to all who are authorities on heat the feasibility of constructing a structure of bombs or retorts, vented or not, each capable of restraining 10,000 to 50,000 lb. of ignited fuel, at an elevation, and also filling with customary taste and beauty the needs of utility and health for habitation.

25 The fireproof building has unequalled habitability and utility and also lends itself admirably to conversion into a piped building when called for, and even more excellently lends itself to conversion into a building having protected windows.

26 *The Horizontally Divided Building* is designed to hold a fire from rising through the floors. Repeated experience has proven for large area buildings that excessively large and dangerous fires develop quickly if the floors are not fire tight.

27 Such horizontal division is obviously of no value against a hot-blast fire moving laterally from without, and it also does not prevent an internal fire from jumping from floor to floor on the outside of the building.

28 Horizontal fire-tight construction is very rarely found

when fire-tested, its worst drawback being that in the opinion of the public it injures the habitability and utility of the building, hence all sorts of concessions are made.

29 *The Protected Widow.* Protected windows can debar city conflagrations, but do not because there are too few of them, except in a few special and minor localities.

30 *The Piped Building.* The building piped with fusible outlets, whether with automatic water supply or with water promptly applied, can but does not debar city conflagrations for the same reason given respecting the protected window.

MEASURES WHICH CAN DEBAR CONFLAGRATION

31 From the foregoing it appears that the fire limits, the water supply and the fire department are already well developed and do cope with all fires except the true conflagration types of hot blast from without the town proper, or an in-town fire which speedily ramifies through innumerable windows.

32 Against such misfortune we have the successful deflection experiences, and the successful absorption experiences mentioned at the beginning.

DEBARMENT OF CONFLAGRATIONS BY DEFLECTION

33 Taking up the deflection idea first, it is obvious that the walls of existing buildings must be used as deflectors and, as common glass has no fire resisting qualities, the window openings must be closed by shutters, or wired glass in metal sash, or equivalent.

34 Experience shows that when a hot blast reaches a building so prepared as a deflector, failure at first ensues, the heat promptly radiates through the wired glass and ignites the contents of the building, or the shutters leak heat, and the contents inside ignite.

35 Nevertheless, there is a retard effect, and it is obvious that if other buildings located to the right or left of the center of the hot blast have window openings similarly stopped, they must suffer less and the elsewise lateral ramification of the fire decrease.

36 The hot blast is thus largely deflected upward, partly checked and less able to cross the next street or alley, assuming protected windows throughout.

37 Just how many deflector walls and air spaces could be

jumped or burned through by a conflagration of given severity is a matter of judgment based on observation, precisely as the extinguishing power of a hose stream is a matter of judgment from experience, not reducible to exact figures.

38 The writer submits, however, that if all the alley windows were protected and also all the street windows on the second floors and above in the solid three and four-story parts of a town, an outlying district fire, a conflagration could not then bore a hole or a bay into such a district deeper than through four deflector walls and across three air spaces, which would mean two blocks and three streets, or a very wide block with its streets, if divided by an alley.

39 Not that the fire would be put out, nor that tongues and fire brands would not have to be taken care of; but that the hot blast would be deflected upward so the firemen could take a front stand and the general ramification of the fire cease to a state of normal fire department control.

DEBARMENT OF CONFLAGRATIONS BY ABSORPTION

40 There remains but one other known means to regain control of a conflagration, that of absorbing the hot blast by means of the piped building. Experience has demonstrated that a hot blast can be absorbed by a spray if the spray be very deep and fairly housed from the wind as is true of the cage of spray represented by a sprinkler installation in full action in a building whose windows have burned out.

41 The most notable demonstration of this was the Brown-Durell sprinklered building at Boston in 1893. Inasmuch as this building constituted a single large cage of spray which absorbed the main body of a down-town fire that was wholly beyond control, it is certain that a row of such cages of spray, if placed at least two or more deep, would always accomplish the same thing, and do so without the aid of protected windows.

42 The writer submits that if a city throughout all of its three and four-story and higher parts be composed exclusively of suitably piped buildings, and special water supply be provided at the border for at least one block wide, a conflagration from cheap district stuff without could not burn across a street, through a block deep of spray, and across the next street.

43 As before, the fire would not be put out and fire brands would still have to be taken care of; but there would be no rami-

fication of fire in the sprinklered territory and there would be a full restoration of normal fire department control.

VALUES, COSTS, GAINS

44 The Boston big fires proved out burnable property values at a rate of over $500,000,000 per square mile, and it is well known that today there are several city centers which have grown to a far higher rate of concentration of value.

45 To estimate the effect of debarring conflagration from a city district by retaining the fire limits, the fire department and the water supply, and adding thereto by equipping all buildings within such district with protected windows or piped buildings, it seems fair to assume $250,000,000 per square mile as typical of average burnable values over the central districts of our twenty leading cities.

46 For such a square mile, standard automatic sprinkler equipment (including masonry) would cost about four per cent of the burnable values, or $10,000,000 per each square mile with fixed charges of about 16 per cent per year.

47 Plain piped buildings and protected windows would each cost about half as much, or $5,000,000 per square mile for either, and each would have fixed charges (about the same as the buildings), about 9 per cent.

48 The savings which can be computed for such a square mile, with protected windows or with piped buildings throughout, per $100 of burnable values per year, would be:

(*A*)	Elimination of conflagration risk (as per records)................	$0.33
(*B*)	Reduction of every-day fire cost due to exposure between individual buildings (tariff rebate)......................................	0.07
(*C*)	Reduction of fire cost occurring within standard equipped sprinklered building (tariff rebate)......................................	0.80
(*D*)	Same as *C*, but for plain piped buildings (shown later)..........	0.45

49 Applying the foregoing on a basis of sprinklered buildings alone throughout the square mile, shows investment $10,-000,000; fixed charges or loss $1,600,000 or 16 per cent. Gain *A*, $825,000 or 8.25 per cent. Gain *B*, $175,000 or 1.75 per cent. Gain *C*, $2,000,000 or 20 per cent. Net gain of $1,400,000 or 14 per cent.

50 Similarly and solely for protected windows shows investment of $5,000,000 fixed charges, or loss $450,000, or 9 per cent. Gain *A*, $825,000 or 16.5 per cent. Gain *B*, $175,000 or 3.5 per

cent. Gain *C* or *D* nominal. Net gain of $550,000 or 11 per cent.

51 Similarly and solely for plain piped buildings shows investment of $5,000,000, fixed charges or loss $450,000 or 9 per cent. Gain *A*, $825,000 or 16.5 per cent. Gain *B*, $175,000 or 3.5 per cent. Gain *D*, $1,125,000 or 22.5 per cent. Net gain $1,675,000 or 33.5 per cent.

52 In surveying any actual square mile it would develop that but one of the three, viz., protected windows, automatic pipes, or plain pipes, would best suit any one building, and this would be likely to result in a detail plan calling for gross investment of about three per cent of the burnable values at a net gain of about 18 per cent.

53 But figures cannot include the grief, loss of work and trade following every large conflagration.

RESUMÉ OF ADVANTAGES AND DISADVANTAGES

54 Thus far this paper has attempted to show that our fire limits, fire departments and waterworks are today well developed, and that protected windows or piped buildings throughout the costlier districts are all that is needed, in order to debar conflagrations.

55 The fire limits, the fire department and the waterworks are too well known to need further comment. To recapitulate the advantages and disadvantages of the protected window and the two types of piped buildings:

56 The protected window delays the entry of severe fires and also prevents general ramification of fire through innumerable window openings.

57 Not that the protected window does this perfectly, because shutters may be out of order or not get-at-able to close if open, and because wired glass transmits heat by radiation very rapidly. Nevertheless, as aided by existing air spaces, alleys and streets, the protected window is a proven success in practice, whenever its application is general.

58 The protected window is beginning to be required in building codes; it also is tangible to the public eye, something that can be seen as representing a fire stop or check; it has a simple technical structure and therefore is much in the nature of a market staple.

59 When in wired glass form it has some working advantages, at least for skylights, and finds favor with architects on

the better class of buildings. When in the form of shutters, the fire-stop effect is better than for wired glass, but this is largely offset by the fact that shutters do not get the care which comes to a window which is in more or less constant use.

60 The advantage of the piped building with automatic double-source water supply, the well known sprinklered building, is first of all the protection to life that is afforded. Apparently this specific form of fire protection is the only one which to any dependable degree conserves life. An experience with say 10,000 buildings over a period of about 15 years gives rise to the statement that no life has ever been lost in a building so equipped, either by fire or smoke, and to the best of the writer's knowledge this is literally true.

61 While it is true that fires occurring under sprinklers are by no means invariably put out without issue of smoke, the fact is that the operation of an automatic sprinkler system develops a powerful drenching spray not only on the fire but around it, and compels escaping smoke to pass through a dense spray; and the presumption is that the spray takes up the acrid quality and heavier carbon contents of the smoke, and thus has much to do with the proven fact of protection to life.

62 While mathematical safety against loss of life by fire is probably impossible, it is within the truth to say that where people are in masses, or are asleep, safety cannot exist if the main hazards are not under the automatic sprinkler.

63 A second advantage of the automatic sprinkler system, and the one most in point under the title of this paper, is that it has been found in practice that, given brick buildings, well secured pipes, and reasonable water supply, a fire even when of conflagration magnitude cannot burn completely through such spray further than the depth of one, or say two, buildings, thereby debarring far spread of fire from without into such a district.

64 A third advantage of this type of piped building is that the fires are put out so quickly and with such economy of water by reason of its accurate application, and with so little smoke and so great a reduction of the harmful quality of the smoke that the aggregate fire, water, and smoke damage to goods is far less than for any other form of protection.

65 The main advantage of the plain piped building, or building equipped with automatic sprinklers on empty piping with exterior hose coupling for fire department use and relying solely

on the fire department for water supply, is that the first cost and fixed charges make it applicable to the medium value buildings.

66 Another advantage is that of safety to life, compared with that of buildings not piped at all, because in practice the piping and sprinklers can be operated nearly as quickly, and necessarily to the same effect as do automatic water-supplied sprinklers.

67 Still another advantage is that the technique and upkeep essential to efficiency are far less than with the full standard automatic sprinkler equipment.

68 The main disadvantage of the protected window is that it is non-commercial in the every-day sense, inasmuch as it protects only between neighboring buildings and this saving averages too small to cover its fixed charges through cheaper insurance, particularly as it saves but little on the cost of fires originating within the building itself.

69 A disadvantage of the first form of piped building (with standard automatic sprinkler system) is that it is a special engineering product, technical to a high degree, yet depending on this quality for its efficiency, an efficiency seemingly possible to maintain, yet so far only by a few skilled contractors and experts. The system therefore is open to criticism by all who rail at any control of skill or service.

70 Another objection to this form of piped building as it now is applied in the field is that its water supplies are very liberally taken in the form of large pipes direct from city mains through the influence of large property owners, thereby saving them expense of providing private water supply. For Manhattan Island and for Chicago this is not serious because in these two locations city water is of too low a pressure to be generally available for such supply. But in some of our cities there are too few sprinklered buildings to check a conflagration and just about enough of them to jeopardize complete crippling of waterworks and fire department at a time of conflagration by reason of these buildings being wrecked in detail and bleeding the general water supply through the breaking of large pipes.

71 Hence another disadvantage, or at least a special requirement for a piped district, would be that the border of such district would require to be provided with water supply in a manner not to jeopardize the general hydrant system of the city; and this in turn would necessitate a special border pipe line into which water would be pumped or admitted under control.

72 Still another disadvantage of standard automatic sprinkler equipment is that it is expensive in first cost and in fixed charges. The investment and fixed charges do not have any fairly constant relation to the value of each individual building plus contents, and also at city labor costs are usually excessive, except for the fewer large and fairly high buildings.

73 A disadvantage of the plain or empty pipe sprinkler system is that this mode of protection has as yet but few applications; no extended study has been given the art of cheap extinguishment of fire in medium value property. Another disadvantage is that fire department practice is at variance; some chiefs favor and ask for such equipment, and others evade or object to any change or extension of present methods.

74 It does not seem to be generally realized that a building in a down-town district does not burn badly before the department arrives. Were this not so, any modern fire department would not, as the records show year after year, hold the fires within moderate loss, except 0.003 to 0.005 of the total. It is a fact that the fire department does arrive (except in the suburbs) while the fires are yet incipient, though perhaps inaccessible. It seems to be accepted as a matter of course that a costly proportion of buildings shall burn and soak, subsequent to the arrival of the department, for the sole reason that the department cannot quickly put ample water where, and only where, it is needed. Yet to do the latter is all that the standard automatic sprinkler equipment does or professes to do, and as much if not more water can be supplied to empty pipes nearly as quickly by firemen as by a private tank.

75 Even in a case of purposely delayed alarm and sprinklers shut off (incendiary), the writer has seen work done in this manner by only one steamer with wonderful success, extinguishing a four-story fire which otherwise would have required many hose streams, and this after there was no time to lay so much hose, much less set up ladders and crews.

76 The fire cost of plain piped buildings would admittedly be greater than for a standard sprinkler equipment because while there would be no failures through tanks down or pipes frozen or valves shut off, the fire department would not put water on the fires at quite as early a stage of incipiency.

77 A willing fire department, however, would put water on the fire through such pipes while a fire was yet incipient, because

our fire department records show that the vast majority of downtown fires are not put out while incipient by quick work with light appliances.

78 To pay for the larger surface fires and the greater number of sprinkler heads or fusible outlets which would therefore open and make water damage in practice with plain pipes as compared with standard automatic sprinkler equipment, the figures given earlier allow for the typical square mile, $875,000 per year, which would seem excessive, to say nothing of a further offset of $1,150,000 reduction of annual fixed charges.

79 However, the standard automatic sprinkler system has been fully demonstrated for over 20 years and also about 20 years ago was a little better from an economical point of view, fixed charges considered, than it is today, yet it is but just coming into its own. All of this goes to show that the plain piped building must in turn wait for recognition and extend in application by degrees.

ALLOWABLE HEIGHTS AND AREAS FOR FACTORY BUILDINGS

By Ira H. Woolson

ABSTRACT OF PAPER

Factory buildings of excessive heights or areas have long been recognized by underwriting organizations as a grave danger to life and property, owing to the difficulty of controlling fires in them. The men best fitted to determine safe limits of heights and areas are fire marshals and fire chiefs, and accordingly the writer communicated with all such in the United States representing cities of over 20,000 population. Replies were received from 117 representative cities; these have been summarized and form the basis of the paper.

ALLOWABLE HEIGHTS AND AREAS FOR FACTORY BUILDINGS

By Ira H. Woolson, New York

Member of the Society

In the design of factory buildings, one of the vital features tending to control the spread of fire is a judicious limitation of height and area. It is self-evident that whatever restricts a fire reduces the life hazard. Owing to the supreme importance of these two subjects, a person contemplating the erection of a building of this class should give careful consideration to the history of fires in such buildings, and the experience gained in fighting them. The question is more acute in this class of buildings than in any other because of the fire hazard which exists in them, and the economic advantages due to reduced costs in construction and supervision, when several large areas are housed under a single roof. Just where to draw the line so as to produce reasonable safety without prejudice to building investments is the problem.

2 Factory buildings of excessive heights or areas have long been recognized by underwriting organizations as a grave danger to life and property, owing to the difficulty of controlling fires in them. They have for years urged limitations which have been freely ignored by ambitious architects and factory owners, because the suggested restrictions were considered unreasonably drastic. The evidence produced in this paper strongly supports the limitations which were advocated.

3 It is logical to assume that the men best fitted to determine safe limits of heights and areas are the men who have made a life work of combatting fires under all conditions of weather and hazard. With this idea in mind, the writer communicated with all the fire marshals and fire chiefs in the United States representing cities of over 20,000 population. A set of eight questions and a letter of explanation were sent to each. Fire chiefs as a class

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

are not good technical correspondents, therefore it was not surprising that only one-third of the men addressed responded to the appeal. However, replies were received from 117 representative cities well distributed as to size and geographical location. These have been summarized and form the basis of this paper. A few of the replies indicated a misunderstanding of the questions, and these were discarded. The questions were as follows:

1 What should be the greatest height allowed for manufacturing or warehouse buildings *without sprinkler equipment?*

Brick and joist construction...............Height in ft.—or No. of Stories—
Fireproof construction....................Height in ft.—or No. of Stories—

2 Take the same question as No. 1, but assume the buildings to be fully equipped *with automatic sprinklers.* What height would you approve?

Brick and joist construction...............Height in ft.—or No. of Stories—
Fireproof construction....................Height in ft.—or No. of Stories—

3 What should be the greatest floor area allowed in the same class of buildings *without sprinkler equipment?*

Brick and joist construction.......Area in sq. ft.—or Width—ft. Length—ft.
Fireproof construction............Area in sq. ft.—or Width—ft. Length—ft.

4 If the same buildings were fully equipped *with automatic sprinklers* what area would you approve?

Brick and joist construction.......Area in sq. ft.—or Width—ft. Length—ft.
Fireproof construction............Area in sq. ft.—or Width—ft. Length—ft.

4 Each building was assumed as a good one of its class, with enclosed stairways and elevator shafts; and the chiefs were requested to base their answers upon experience in fighting fires in the class of buildings described, and to assume restrictions which would afford a reasonable chance of controlling a fire on any floor.

TABLE 1 GENERAL AVERAGE OF 99 TO 111 REPLIES RECEIVED FROM ALL CLASSES OF CITIES [1]

Type of Building	Stories in Height	Area between Fire Walls in Sq. Ft.
Non-Fireproof, not Sprinklered	3.1	6,300
Fireproof, not Sprinklered	4.9	12,300
Non-Fireproof, Sprinklered	4.6	12,800
Fireproof, Sprinklered	7.0	27,100

Average story height was 12 to 13 ft.

5 Naturally, and quite properly, the replies reflect the local conditions, such as the efficiency of the fire department, the water pressure, the combustibility of the goods being manufactured,

[1] The variation in the number of replies (averaged) resulted from some incomplete answers.

the number of sprinkler equipments in service, and the degree of congestion among the buildings. However, all conditions were represented, and the summary of so large a number of opinions should indicate fairly well the average condition throughout the country. (See Table 1.)

6 The answers regarding allowable heights were much more uniform than those relative to area. It is significant that 83 per cent of the replies would limit the height of a fireproof sprinklered factory building to less than ten stories. The opinions in reference to height of the other classes of buildings were exceedingly uniform, and consistently low.

7 Replies as to permissible areas in sprinklered buildings were widely divergent, but for the unsprinklered classes they were more uniform than would naturally be expected considering the great diversity of conditions under which they were prepared.

8 It is evident from the figures given, that the fire chiefs have no settled policy among themselves as to the credit that should be given to an automatic sprinkler equipment as a fire extinguishing device. A few enthusiasts would permit unlimited area in a sprinklered building, while on the other hand a considerable number would give very little or no increase, when sprinklers are installed. Two chiefs stated that their unfortunate experiences with sprinklers had caused them to lose faith in their reliability. As a whole, however, they are strongly in favor of sprinklers and are inclined to permit over generous areas in buildings so equipped.

9 In order that the replies may be intelligently interpreted they have been separated into three groups, Tables 2, 3, 4, according to size of the city represented, and each group has been analyzed to show the character of the answers given to each question.

10 In the cases referred to by an asterisk, where no limits to areas were given, they were not included in the averages, but were counted in the columns giving the number of answers above the average. In each group it will be noted that about the same number of men gave high answers to all questions, the proportion being one-quarter to one-half of the number in the group. The uniformity of height limits, and the lack of it in the area limits, is very apparent in all groups. It will be noted that the largest area values are given in Groups I and II, comprising the smaller cities. This is significant, and needs explanation.

TABLE 2. GROUP I SUMMARY OF ANSWERS FROM 52 CITIES WITH A POPULATION OF 20,000 TO 50,000

Type of Building	Stories in Height			Answers above Average	Area in Square Feet			Answers above Average
	Average	Max.	Min.		Average	Max.	Min.	
Non-Fireproof, not Sprinklered................	2.8	6	1	13	6,000	20,000	1,150	15
Fireproof, not Sprinklered..	4.4	10	2	24	12,600	60,000	1,150	15
Non-Fireproof, Sprinklered	4.1	8	2	17	12,300	*60,000	3,000	17
Fireproof, Sprinklered.....	6.3	12	3	18	27,300	*180,000	5,000	20

* Four votes received in favor of "no limit to area" in this class.

TABLE 3. GROUP II SUMMARY OF ANSWERS FROM 23 CITIES WITH A POPULATION OF 50,000 TO 100,000

Type of Building	Stories in Height			Answers above Average	Area in Square Feet			Answers above Average
	Average	Max.	Min.		Average	Max.	Min.	
Non-Fireproof, not Sprinklered................	3.2	6	1	8	8,300	40,000	2,500	5
Fireproof, not Sprinklered..	5.2	10	1	6	14,800	60,000	2,400	4
Non-Fireproof, Sprinklered	4.8	10	3	5	16,300	75,000	1,500	5
Fireproof, Sprinklered.....	7.7	20	4	5	36,300	200,000	4,000	5

TABLE 4. GROUP III SUMMARY OF ANSWERS FROM 36 CITIES WITH A POPULATION OF 100,000 AND OVER

Type of Building	Stories in Height			Answers above Average	Area in Square Feet			Answers above Average
	Average	Max.	Min.		Average	Max.	Min.	
Non-Fireproof, not Sprinklered................	3.5	7	1	17	5,400	10,000	900	15
Fireproof, not Sprinklered..	5.3	9	2	18	9,800	22,500	2,400	10
Non-Fireproof, Sprinklered	5.0	10	3	15	11,300	22,500	900	13
Fireproof, Sprinklered.....	7.5	12	4	16	19,400	*80,000	2,500	9

* Two votes received in favor of "no limit to area" in this class.

11 Occasionally the fire chief of a small city has experience which would abundantly qualify him to estimate properly the merits of fireproof construction and sprinkler equipments; more often, however, his city has meager protection of this kind, and consequently he has little opportunity to judge of their efficiency, and it is not strange that he should be a bit extravagant in the credit he would give them.

12 The most rigid restrictions on area are found in Group III embracing the large cities. As fireproof construction and sprinkler equipments are common in most of our large cities, it is reasonable to assume that the fire chiefs of such cities would have had much more experience with such methods of protection, and be better able to decide what increase should be given in the size of a building when such protection is provided, than their less experienced fellow officers in smaller towns. It is thought quite proper to assume that their figures are more nearly correct and should be given the most weight.

13 Significant evidence in support of this argument is found in the fact that four chiefs who give no limit to areas in non-fireproof and fireproof sprinklered buildings are located in cities having a population of less than 50,000 in which there are few fireproof factory buildings or sprinkler equipments. On the other hand only two chiefs, in cities over 100,000 population, suggest a "no limit area" in a fireproof sprinklered building, and none approves such areas for non-fireproof buildings.

14 With these thoughts in view, Table 1 has been changed somewhat to be more in accord with the weight of evidence. It is believed, therefore, that Table 5 represents more correctly the consensus of opinion among the fire chiefs of the country best qualified to judge as to what should be the proper limits of height and area for factory buildings.

TABLE 5 ALLOWABLE HEIGHTS AND AREAS IN FACTORY BUILDINGS

Type of Building	Stories in Height	Area between Fire Walls in Sq. Ft.
Brick and Joist Construction, not Sprinklered.	3	6,000
Fireproof Construction, not Sprinklered......	5	10,000
Brick and Joist Construction, Sprinklered....	5	13,000
Fireproof Construction, Sprinklered..........	7	20,000

15 These values might be increased somewhat under the influence of especially favorable local conditions, as previously explained, but the writer submits that as they represent the average

deliberate judgment of such a large body of men, so well qualified to estimate the hazard which the values involve, they should be given careful consideration, and should be increased only with the utmost caution.

EXTRACTS FROM FIRE CHIEFS' LETTERS

16 The following extracts from letters received from different fire chiefs in connection with this investigation may be of interest as indicating their attitude of mind in relation to the questions asked:

"In my opinion, from a fire-fighting standpoint, *no building* should be built over eight stories."

"In our city there is room to grow on the ground without building high in the air. It is almost impossible for a public fire department to fight a fire from the outside above 75 ft."

"The figures given mean that every 66 ft. by 66 ft. should have a brick wall through length of building with Underwriters' doors; same to be double. As for width, in no case over 66 ft. wide; with solid wall, same to reach above roof at least 6 ft. *Build on ground not in air.*"

"A building 8 or 10 stories high, out in the open where it can be attacked from all sides should be handled very readily by a modern equipped fire department."

"I think that a factory should never be more than four stories high. I almost feel that there is no such thing as fireproof construction from my own experience. I know that it is possible to store enough material in any building to burn it. I am very much in favor of dividing rooms in factories with fire-resisting walls, provided with automatic fire doors."

"While fireproof construction is the best, it is the contents placed therein that is the hazard to life and property. Buildings should not be constructed to a greater height than can be reached by fire department ladders; 85 ft. to upper windows."

"In my opinion no warehouse building ought to be over one story in height. In regard to manufacturing buildings, I will say that I do not approve of any of these buildings being over three stories in height. If they want room, let them build in length and not so high; that is just what makes such bad fires. These buildings have all kinds of combustible material in them and they are sure to jump to another building if they are four or five stories in height."

"It is my opinion that all buildings for manufacturing and warehouses should be sprinklered, and not built higher than what the water supply will furnish and cover."

"Do not think any fire department can successfully fight a large fire over six stories high, and ten stories allowed only when there are two sources of water supply with good pressure."

"Area of sprinklered and unsprinklered buildings should be about the same, on account of increase in height allowed for fireproof buildings."

"All buildings of character named should be sprinklered."

"Joisted brick construction should not be allowed without sprinklers."

"I think a good sprinkler system is one of the best fire preventions that has

been invented in a great many years, and if kept up properly, it is pretty hard for fires to get away."

"If I had my way I would not allow any manufacturing plant to do business until it were properly sprinklered. It does things when they should be done."

"My experience with the 28 factories in this city has been that the sprinkler systems are out of order much of the time. Not looked after properly."

"This department has had no unfortunate experience with the sprinkler system, but, I do not feel inclined to depend upon them."

"The reason for not showing more favor to sprinklered risks, is because our experience with sprinkler systems in this city has shown them to be unsatisfactory, and not to be depended on."

"Stairs should be of steel without any wood sides; if any wood in the construction then there should be sprinklers. Should be sprinklers in all elevators even if they are enclosed, for an elevator is a bad air shaft. Brick factories cut up with wooden partitions are generally hard fires to fight."

"I do not approve of small rooms in factories, they make it very hard for a fireman to fight his way through smoke trying to find a fire when a building of this kind is partitioned off so much."

"In considering the limiting of height and area of a building, the question of accessibility should play an important part."

STEEL PASSENGER CAR DESIGN

In the May issue of The Journal was published a collection of 13 papers upon the subject of Steel Passenger Car Design, given at the New York meeting of the Society on April 8. The discussion which followed the presentation of these papers at the meeting is published herewith.

DISCUSSION

George Gibbs. On this occasion when the subject of steel passenger car design is under discussion, it may be of interest to make a brief reference to the early history of this important innovation in railway operation which had its origin in connection with the provision of car equipment for the first rapid transit subway in the City of New York. The writer was at that time consulting engineer of the subway construction company in charge of car design and construction. It was obvious that the exacting requirements of the contemplated service, which involved tunnel operation at a high schedule speed with closely spaced trains crowded with passengers, must be conducted with all possible precaution against accident and, further, in a way such as to minimize the fatal consequences of any accident which might occur in spite of such precautions. The two consequences most to be feared from an accident are the breaking up of the cars in the train and the setting of a fire in the wreckage; on an open railway line the consequences of these are serious enough, but in a subway or tunnel they are potentially much worse, because of the confined space which prevents the prompt escape of passengers from the wreckage.

Cars for such service, therefore, should be protected in an unusual degree against the possibility of telescoping in an accident, and the electric apparatus should be installed in a way such as absolutely to prevent the setting of fires. Incombustible metal cars were naturally suggested as the solution of the problem, but

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in the latter part of 1901, when the question of car design was taken up for the subway, it seemed impracticable to consider the adoption of an all-steel car for the large amount of equipment required, because of the fact that no practical steel passenger cars had ever been constructed and it was evident that to develop a serviceable type a number of very serious mechanical problems had to be attacked by thorough study and experimentation. Not least among the problems was that of keeping the weight of a metal car within reasonable bounds, without sacrificing its strength and serviceability; light weight being an essential requirement in rapid transit operation.

As the best practical solution of the car question, it was, therefore, decided to provide wooden cars initially, but to make them of an advanced type with metal underframes, protected floors and copper-sheathed sides, and to mount the electric apparatus in incombustible envelopes. These cars were rightly considered at the time a great advance upon previous practice in safeguarding against accidental fires. The first lot of 500 of these protected wooden type subway cars was ordered in December 1902.

While it was necessary to insure the operation of the subway at the date set for its opening by providing the initial car equipment, the writer believed the steel car feasible, and in this view he was encouraged by George Westinghouse, under whose stimulating advice he was led to persevere in efforts to develop a metal car at the earliest possible date. A. J. Cassatt, president of the Pennsylvania Railroad, was also impressed with the necessity for noncombustible cars in tunnel service, as the great project of the Pennsylvania road in building a tunnel entrance into New York City was then in progress. He accordingly offered to the subway company the facilities of the Altoona shops to build, in the quickest possible time, a sample steel car, the design of which the writer had completed in October 1902. August Belmont, president of the Rapid Transit Subway Construction Company, concurred in this arrangement and early in 1903 the Altoona shops started upon the construction of this car, which was completed in December of that year. Realizing the many difficulties which would be encountered in getting material promptly at that time, commercial shapes were quite generally used in the design, and the car as built was found, therefore, to be quite heavy and not altogether sightly in appearance.

The company still needed 300 cars to complete the early re-

quirements of the subway operation and it became a question of immediate necessity to determine whether these cars should be of wood or be of the all-steel construction. The writer was able, from experience with the sample car, to develop a new design and at a meeting of the executive committee of the subway construction company early in 1904, he definitely recommended the letting of contract for 200 of the new design of steel cars. On the strong endorsement of E. P. Bryan, general manager of the road, Mr. Belmont decided to venture upon this important innovation in railroad operation. The contract for the 200 steel cars was accordingly let in March 1904, and followed October of the same year by 100 more. Both these contracts were taken by the American Car & Foundry Company, which had the courage of its convictions in assuming the heavy responsibility of turning out these large orders at specified time and at a price which was not out of line with that of the previous wooden cars. A number of these cars were received in time for the opening of the subway, October 27, 1904, and are running today.

During the same year the writer, who also had charge of the electrification of the Long Island Railroad, placed an order for 122 steel electric motor cars of practically the same design as the subway cars; this service started June 28, 1905. The Long Island was the first steam railroad in the country to adopt steel cars for its passenger service.

The New York Central a year later placed an order for 125 steel cars and inaugurated their electric service from the Grand Central Station in January 1907.

The Pennsylvania Railroad, as result of the progressive action of Mr. Cassatt, endorsed by Samuel Rea, then vice-president of the company, adopted steel passenger cars for all trains coming into the new terminal, a decision which has since had a far-reaching effect upon the standards of all railways of the country. The question of the best design for through passenger train cars was taken up exhaustively and systematically by this company and was made the subject of a report by a special committee of its operating officials in May 1909. Today this company has in service 2139 steel passenger cars, excluding a large number of sleeping and parlor cars of the Pullman Company, and builds no other type.

William F. Kiesel, Jr. The method of suspension described by Mr. Summers may be very good on short cars, but with long

cars, especially passenger cars, it does not seem sufficiently flexible in the trucks to avoid unbalancing and putting the cars out of shape. The bodies are long and the cars have some flexibility, but in some cases the tracks are such that it is necessary to have excessive provisions for flexibility aside from that in the truck.

John A. Pilcher. Referring to Par. 2 of Mr. Summers' paper on Suspension of Steel Cars, the question of the amount of wind that has to be taken up between the two trucks on the car seems to be exaggerated; in approaching a curve the rise in elevation of the outer rail is about 1 in. in 50 ft. On the ordinary modern passenger car truck centers are about 50 ft. apart so that the total amount of wind is about 1 in. measured at the rails. Considering the car weighs 130,000 lb., with trucks approximately 20,000 lb. each, and the car body about 90,000 lb., in order to take care of the wind in the track, the springs on the diagonals of the car would have to compress ½ in. more than the springs on the opposite diagonal assuming the springs as over the rails. On this same car this would mean that two diagonals would have 20,150 lb., and the opposite two 24,850 lb., or a difference of 4700 lb. This difference in deflection is taken from actual springs.

To analyze this in connection with the swinging hangers, assume these hangers to be 11 in. long, and to be located at an angle with a vertical of 28 deg. 8 min., which is about that shown in the cut, and also assume that they are located approximately over the track (the movement would have to be decreased or increased in proportion to their distance from the rail inside or outside) with a load of 22,500 lb. for each group of hangers.

In order to take care of the same amount of wind in the track as considered in connection with the springs, that is, ½ in. difference in elevation on the opposite sides of the track, the angle would be decreased to 25 deg. 35 min. on one side, and increased to approximately 30 deg. 45 min. on the opposite side in order to bring about stable equilibrium. The vertical loads would amount to 24,935 lb. on one side, and 20,065 lb. on the opposite side, or a difference of 4870 lb., just a little more than when the springs were used. In calculating the deflection of the springs only the deflection of the bolster springs was taken into consideration; the equalizer springs would also have to take an additional load, and would help to reduce the difference of loads necessary to bring about the proper amount of deflection.

Looking at a car from the rear approaching a curve, when the front truck enters the curve the centrifugal force at that point would tend to throw the car body, relative to the truck, actually in the opposite direction from what it should move in order to equalize the stresses. This would put additional torque in the body of the car, which would not be present in the case when springs only take care of this movement. The torque would be rather reduced at the time of entering the curve when the springs only are used.

When both trucks are on the curve all of the wind is out of the car; the centrifugal force in that case throws the car body toward the outside, and would tend to augment the lift in the track on the outside, which is hardly desirable.

Angular hangers, while they may not have been intended for the purpose described, have been in use for a number of years. It is very questionable whether they are of any advantage.

S. A. Bullock. Mr. Pilcher referred to frictionless center plates and adjustable side bearings to reduce to a minimum the oscillation of the car. My experience has been that, to prevent the nosing of a car, which takes place almost entirely upon a tangent, it is necessary to transfer the entire weight from the center plate to the side bearings. Cars of the Pennsylvania Railroad design have been running in the Hudson & Manhattan Subway, and, although they have very short centers, it was found necessary, in order to prevent the nosing of the cars, to take as much weight as possible from the center plates and to put it on the side bearings. All of the weight would have thus been transferred had not the cars been designed with light side sills. It happens in this particular case that the distance center to center of the trucks was exceedingly small, but, even on long steel passenger cars, a saving in wheel flange wear would be effected by taking all of the weight from the center plates and putting it on the side bearings, that is, designing the truck so that immediately the car begins to take or leave the curve, an initial pressure is put upon the truck, which is thus slightly restrained in taking the curve.

This test has been carried out on several railroads. Plaster casts were made of the wheels, and it was found in making outlines of these casts that there is approximately 50 per cent reduction of the wheel flange wear when the radial movement of the truck was restrained in curving.

E. W. Summers.[1] In writing a ten-minute paper, it was not possible to go into detail to any extent. The examples given were intended to be only general in character. Of John A. Pilcher's criticism, the 1-in. wind in track in 50-ft. is the ideal condition. Cars cannot be built to operate only under ideal conditions. Wind in track of 4 in. to 5 in. in the length of a car is frequently encountered when the alignment of the rails is disturbed by water or weather conditions. It is the abnormal conditions that cause wrecks.

In making his comparisons, Mr. Pilcher has apparently neglected the action of springs which are included in the inclined-hanger arrangement. If the inclined hangers make vertical adjustment on account of the tracks being in wind, the springs will not have that to do. As a matter of fact, both the springs and the hangers make some of the adjustment, neither one doing all of it.

As evidence that the vertical reactions given by him are incorrect, compare the ordinary center-bearing truck under a freight car with an inclined-hanger truck such as illustrated in Fig. 1 in the paper, Suspension of Steel Cars, and used under a similar car.

The center-bearing truck must have side bearings, which will be located, say, outside of the wheels in line with the center of the side frame as located on the inclined-hanger truck. Any experienced railroad man knows that side bearings so placed on a center-bearing truck, under such a car, will cause derailment, even on comparatively straight track. On twisted track the weight of the car outside of the wheel uses the wheel as a fulcrum and relieves the load on the opposite wheel, allowing its flange to climb the rail.

It is a matter of record that new refrigerator cars which are comparatively rigid, having side bearings in line with the wheel, easily leave the rails where the track surface is warped.

Contrast these with the inclined-hanger truck having its side bearings outside the wheels and over the center of the side frames under an absolutely rigid all-steel box car, and note that these cars have traversed the worst terminal tracks that could be found at higher speed than the engineman dared to follow with his engine without any indication of wheel lifting, and it is clear that Mr. Pilcher's reactions are in error.

[1] President, Summers Steel Car Company, Pittsburgh, Pa.

As a comparison with his spring deflection taken from actual springs, some five years ago the writer built an all-steel box car equipped with side bearings directly in line with the truck side frame and M.C.B. springs for a 50-ton car. When attempting to take this car on its own wheels from the riveting shop to the paint shop at the works where it was manufactured it was derailed six times, due to the side bearings being outside of the wheels and warped track surface. The side-bearing, inclined-hanger arrangement was applied to this car, no change whatever being made in the spring arrangement, and the car then traversed the worst tracks to be found around the works and has continued in regular interchange service on the railroads ever since with no indication of derailment or torsional injury to the car body.

Now, it is clear that with six-wheel trucks weighing as much as a whole freight car, trucks and all, when under a passenger car body of comparatively light weight, the truck weight is sufficient to overbalance the outside load from the body side bearing. The conditions which cause freight car derailments, that is, load reaction on diagonal corners are, however, still in the passenger cars; the excessive comparative weight of the trúcks with that of the car body prevent showing up the car body twist by derailment. The inclined-hanger arrangement relieves this twist. It makes it possible to carry the entire load on the side bearings, directly over the truck side frames. It does away with transverse oscillation or rocking and in so doing prevents nosing. With it, the heavy body and truck bolsters are not required as the load is dropped directly from the car side girders into the truck side frames.

INDUSTRIAL EDUCATION

By F. J. Trinder [1], New Britain, Conn.

Non-Member

In discussing the subject of trade education, engineers should be governed by the true spirit of analysis, and analysis of this subject will show that while it goes beyond the elastic limit or the ultimate strength of the physical bodies with which we are accustomed to deal, it nevertheless has a vital bearing on the successful work of the engineer, in that training in trade education gives to the manufacturing world constructive workers of pronounced ability, able to interpret correctly the design, and to construct loyally according to the principle laid down by the engineer, thus assuring a synchronizing of effort as against the work of men who simply grew up in the work of a mechanic without the quality of a systematic training.

For many years the education of the boy and the girl at public expense has been along lines laid out by instructors who saw only one side of the educational problem and with one result, that of formulating a common course of study for each grade or room and requiring both boys and girls to carry on the work, regardless of the needs of the individual for a more specific training in order to earn a living. Schools in a farming community had the same corrolation of studies as was used in manufacturing districts, and in many cases applied neither to the farm, business nor manufacturing, as the following problems show:

a If in a period of 72 days, 33 1/3 per cent are cloudy, and if it rains 16 2/3 per cent, how many days are rainy?

b If 20 per cent of the days of a common year are stormy, how many days are not stormy?

c John is 15 years old and his sister is 10. His age is how many hundredths more than hers? Hers is how many hundredths less than his?

Can a set of problems more useless than these be conceived?

[1] Superintendent, State Trade Education Shop.

Presented at the New Haven Meeting, November 13, 1912, of The American Society of Mechanical Engineers.

Is it any wonder the boy rebelled against such nonsensical abstract work or that he is determined to leave school and take his chances at some kind of work? To work at what? Certainly not at a specific kind of work for which the school has trained him.

Most engineers have prepared themselves for some specific line of endeavor, decided on the course to pursue and arranged the combination of elements that make for success. So it should be with our public schools and scholars.

The State of Connecticut is trying to solve at least one feature of this educational problem. The board of education in 1910 secured the passage of a law creating two trade schools and the legislature appropriated $100,000 for this purpose. After investigation as to the best locality for such schools, New Britain and Bridgeport were decided upon. The building at New Britain occupied by the boys is a mill construction of the saw tooth type, four bays with a floor space of 12,000 sq. ft. The light is ideal and ventilation and heating are easily controlled. The trades now taught are machinist, pattern-making, carpentry, drafting and plumbing, with plans partly under way for the trade of printing and bookbindery.

The machine departments of New Britain and Bridgeport have contracted to build a complete line of drill presses, tool grinders and small engine lathes. We secure from the factories what boys' work they can give us, for instance, bolts. These provide experience in rough and finish turning and threading. The same boys, having drawing and academic work in keeping with all shop work, learn to construct the various types of threads, also to calculate the dimensions of U. S. Standard bolts from diameter. Lectures are given in class rooms on planing tools, jigs and fixtures.

The pattern department includes both wood and metal work and orders are secured from the outside on new work and on repairs. Each apprentice must put his pattern in the sand, ram up his own mold and make a casting.

The carpentry department boys are now building a $1800 three-family house. It has progressed to the stage where the shingling and siding is completed, window frames set and porches finished.

The plumbing department boys have erected all soil pipe, pipes, traps, vents and lavatory connections and are now waiting

for the plastering to be done when they will proceed with the final fitting up of tubs, bowls, etc. The house is scheduled to be completed in ten weeks, provided the plastering and painting to be done by outside firms is not delayed. It is important and necessary to state that the plan of the house and drawings are also the work of the boys. One noticeable fact about this house building is that no one has been privileged to see greater energy and interest manifested by apprentices on any line of work.

Shop time is from 9 to 12, 12:30 to 5:30 every working day of the year except Saturday, when it is from 8 to 12. Class hours for academic work are arranged to suit the needs of the apprentices.

Regarding the system and shop methods: All work is built on a customer's order and to his specifications or that of our own. The apprentices make the drawings, tracing and blue print. Job tickets are furnished through the office on which must be recorded, first the estimate hours of journeyman's labor, and cost of material, then the actual hours of labor as recorded by the apprentice on his daily time card to be approved by the foreman. The efficiency of the apprentice is the result of the estimate in journeyman's hours divided by the actual hours consumed on the job. This gives the boys their percentage of efficiency in terms of journeyman's hours.

One very important requirement of both the instructor and apprentice is the training for speed as well as quality in the work. Often I am asked, "Do you believe in sacrificing quality for speed?" My answer is, "Give the work the quality it demands, no more, no less, but give it also the speed it demands in keeping with the best you can drill the boy to do." It is not fair to the young man you may have graduated from your industrial school if you have trained him with a view to quality of work only, and left out the speed training. If he is trained in both, his work will stand out and indorse your effort as well as his.

My advice is to get away from practice work. It has never trained the boy and never will. Instructors and some superintendents will tell you that just as good work can be done on practice work as on commercial work. Many instructors indorse it because they think there is no way to prove that it is not true. But I have tried it and I have proved my case. Many instructors indorse practice work because in this there is no customer to be

disappointed, or work to be turned back on account of defects. Was there ever a factory so successful that errors and defects never occurred? It may be that defects of a drawing are carried into a pattern; many patterns not made correctly to drawing; the error found in castings when ready to be machined.

A very important factor in the training of the boy, and one that is difficult to meet, is in securing the right kind of instructors. Several qualifications are necessary:

a He must be a clean good timbered man

b He must be a good mechanic in his line

c A man who can win the love and respect of the boy

d A man who will not tire in the day's work, but will keep moving. He must have " eyes in the back of his head " so to speak, and be gifted with a sense of the fitness of things by which to determine correctly if the boy is in the very best place suited to him.

e He must be a man with an analytical mind, strong in the principles of coöperation and a determination to obtain results.

I ask engineers to lend assistance in this work of trade education; to become associated with such educators as Mr. A. L. Rohrer, electrical superintendent of the General Electric Company, and Mr. Charles D. Hine of the State Board of Education, in promoting the efficiency of the work. The State of Connecticut is a manufacturing state; the people look to the manufacturer for employment; manufacturers are looking for trained mechanics and it is for us to find the shortest distance between the two points, the need and the supply.

The question of supplying trained workers is of vital interest to the United States, and if we hope to hold our own in manufacturing against Germany and other European countries, we must first be prepared to meet the demands for trained workers in all trades. This is no idle statement. It is a condition to be met now and we as engineers having to do with manufacturing will be confronted with a serious problem unless we give attention to this question of trade education.

In the girls' department of the trade shop is taught dressmaking, designing and millinery. The training of these girls has a vital bearing upon the home, that it become provident instead of improvident, happy instead of sorrowful, encouraging in place of discouraging, to the trained mechanic who may be chosen for a husband.

OVERHEAD EXPENSE DISTRIBUTION

By Royal R. Keely, Philadelphia, Pa.
Member of the Society

ABSTRACT OF PAPER

All expenditure in any industry may be divided into three broad classes, labor, material, expense; or more broadly, direct and indirect expense. Direct expense may be defined as all that may be charged directly to the product; indirect expense as all other expense connected with the conduct of the business and which must be borne by the sale of the product.

In a foundry, for example, the labor applied directly in producing a length of cast-iron water pipe is called direct labor expense; that is, it is the labor applied directly to the product of this piece of pipe and is in no way related to other articles that may be produced. The pig iron required in making the length of pipe is direct stores expense. Other labor connected with the administration or supervision is classed as indirect expense. Stores required for repair of building and equipment, office supplies, etc., are classed as indirect stores expense.

In order that the management may intelligently conduct any business, the cost of each article of product should be known. In determining the cost of the length of cast-iron pipe referred to, the labor applied directly in making it, as for instance, the setting up of the mold, pouring of the metal, removing of the pipe from the mold and cleaning it of sand, etc., and the pig iron entering into it, may be charged directly to its cost. But since all expense of the conduct of the business must be borne by the product, this individual length of pipe must bear its share of the expense of supervision, taxes, insurance, depreciation, repairs, heat, light and power, selling and advertising, general office expense, etc.

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The determination of just what its share of these expenses should be has aroused much controversy, and there are in use today six methods of determining this indirect or overhead expense: (*a*) in proportion to material used; (*b*) in proportion to the direct labor charge; (*c*) the time or number of man-hours employed in production; (*d*) machine rates; (*e*) cost numbers or factors; (*f*) prorating by inspection or judgment.

The first of these may be satisfactory if the product is homogeneous, as brick from a brickyard, where if any one kind of brick constitutes one-tenth the product of the plant, this will take one-tenth of the total overhead expense.

The second, that of apportioning expense according to wages paid, is very generally used. Here, if the direct wages paid on any kind of cast-iron pipe are one-tenth the total direct wages for the foundry, then this kind of pipe bears one-tenth of the total overhead expense. The objection to the method is that a job produced by a 40-cent man at a vise and bench would bear the same proportion of overhead expense as one produced by the same man on a large and very expensive machine. This method will be sufficiently accurate only in cases where the workplaces are all of nearly equal value and capacity and the workmen paid fairly uniform wages.

By the third method overhead expense is apportioned by the time spent on the job, instead of the value of the time, as in (*b*). It also does not take account of the equipment.

In the machine hour, or the workplace hour method, the rate is figured to include all expense of maintaining and operating the given workplace, a term broad enough to include everything, from an allotted area where a man may work with a monkey wrench or paint brush to the most complicated and costly machine in the shop.

In a modern office building the income-bearing unit is the office room to be rented, and in fixing the rental account must be taken of all the overhead expense. In a machine shop, each workplace may be regarded as enclosed by four imaginary walls, forming a room of suitable size for the performance of its operation. Each workplace is then considered as a unit in itself from which profit may be made in turning out a product, or it may be rented to an individual workman.

If all the workplaces are rented, then the source of income is not on product sold, but altogether from rental on the available

useful space of the manufacturing plant. All space, however, cannot be turned into rentable workplaces, for there must be general heat, light and power plant, storage space, aisles, halls, passages, offices, etc. The rented space, therefore, must not only maintain and operate the entire shop, but must produce a profit for the owners. Each workplace unit must bear its share of interest and depreciation on its building, interest and depreciation on the cost of machine, taxes, insurance, etc., on the investment, repairs and maintenance of building and equipment, its share of heat, light, power, etc., as well as all other general charges, if it is to make a profit for its owners.

The cost of the product from each workplace is made up of rental, raw material entering into the product, and a fair compensation for the worker, and the selling price must include his profits. The rental of each workplace must be a figure that will enable its operator to make a profit and must at the same time pay all the owner's expenses and make a profit besides. Provision must also be made for the idle time of a workplace.

This indicates the method of arriving at the machine rate. The method is superior to the others in that it takes account of the variation in the cost of production on different types of workplaces, and would be accurate if there were no idle hours. In any system the wages are very carefully charged directly to the item of product, but since the general charges of interest, depreciation, insurance, etc., may be equal to or greater than the wages, it is important to cut these down to a minimum by putting as great a proportion as possible directly against the particular items of product, as in this method.

Mr. Church in his book on Expense Burden, advocates a supplementary rate to dispose of the expense connected with the idle hours and the auxiliary departments, as shipping room, store room, etc. By this plan, expenditure is connected with production centers, the charges being debited to jobs by machine rents or rates so carefully arranged as to include all of them. All floating or general items are collected into a monthly shop-charges account, which is relieved by the total of charges which have been debited during the month by means of machine rates, leaving in the account a residual sum. This sum is reduced by the supplementary rate to an hourly burden, distributed over the jobs in the usual way.

To quote from Mr. Church himself: "It will be obvious that

by this means all the charges will be distributed, leaving nothing in the charges account, and that if all the machines have made full time in the month, the supplementary rate will only represent the floating shop charges. In proportion as machines are idle the supplementary rate will rise, because only working hours are credited to the shop account as per the total of the machine rates found at the end of the month. Thus we secure that each job gets its own expenses only attached to it, plus an average of floating charge and of what surplus may be due to slack times or inefficiency in the shop."

Again he says: "The idleness of a machine may or may not be considered as the fault of that machine. If, for instance, a machine was found to be idle nineteen-twentieths of its time, this might be due to one of two causes. Either the process was rare but essential, or the machine itself was largely superfluous. In the first case it would be eminently fair that the charge should be made very high when it was put in use, since the shop charges due to its presence and upkeep are indubitably incurred for the sake of this occasional use. In the second case it might be rather a matter of accommodation that the machine was retained at all, in which case the shop as a whole should bear the burden and not the unlucky piece of work that should happen to be put on such machine at that time." It is thus seen how this ingenious method puts to each item of product its proper share of overhead charges, for the workplaces which are in use. Then the balance left over, due to idle machines and other auxiliary and general expense, is prorated by a supplementary rate.

In the fifth method, that of cost numbers or factors, which is a simpler system worked out by Frederick W. Taylor in his study of scientific management, the machine rates are determined by a process similar to that already described, and the rates are then treated not as a figure of value, but as a relative number called "relative cost numbers," or simply "cost numbers." If the cost of maintaining and operating two machines is three cents and three dollars per hour respectively, the cost numbers will be three and three hundred respectively. The number of hours each machine runs on any job is multiplied by its cost number. At the end of the period, the total hours by cost numbers for each article or class of product on which it is desired to compute costs and also for the entire shop, are added together. The result obtained is about the same as that reached by Mr. Church's

method, without the complication and extra work of apportioning a second time for the supplementary rate.

In general a rate for apportioning the overhead expense can be established by this method for any class of product and the variation of the rate from period to period will give an accurate indication of the percentage of idle time in connection with this product. The disposal of all shop expense is now provided for. There will be few difficulties in the way of putting the direct labor and stores charge against the article of product into which it enters.

The writer generally accomplishes this result by assigning to the product and stores a definite, concise symbol for each size and kind. The mnemonic system of symbolization, as developed by Mr. Taylor, gives most excellent results. All expense in connection with the conduct of a business is divided, into (*a*) auxiliary, or "A" accounts, as power, stores, shipping, planning, etc.; (*b*) business office, or "B" accounts; (*c*) sales department, or "C" accounts; (*d*) manufacturing departments, or "D" accounts; (*e*) machinery and equipment, or "Y" accounts; (*f*) real estate, or "Z" accounts.

The expenses in connection with the A, D, Y and Z accounts are shop expenses and are disposed of by the method of hours by cost numbers, already described. B and C have no direct relation to shop costs and the expense of these departments may be disposed of by another method to be considered presently. All labor is apportioned by a system of job cards, time stamped at the beginning and again at the end of the job. The sum of the time shown on all these cards must equal the time for which the workman is paid. There is only one job on a card and each card bears the symbol of the product to which the time is charged. The stores are issued from the store room on similar cards. During the period all job cards and stores issue cards are accumulated by symbol in a card index file. At the end of the period the total of all money paid, as represented by the cards, is drawn off by products.

In the classification of expense there is a symbol for each item of expense, both direct and indirect. The direct labor and stores can now be entered at once on the cost card for product turned out. The indirect labor and stores are entered on expense distribution cards, together with other indirect charges, as taxes, insurance, depreciation, etc.

The selling and business office expense, B and C, may be apportioned by a different method, either by direct shop cost, by wages, or by the time consumed in the manufacture of the product, according to the nature of the business. In some cases it may be merged with the shop expense and the total prorated by the method outlined. The usual method is by direct labor cost, or by hours of labor consumed in production.

The sixth method of apportioning the overhead expense, i.e., by inspection or judgment, is one in which the experience and judgment of officials of a company are used in putting this expense where it belongs.

To arrive at a practical method for doing this, the principal items of expense, which may include advertising, catalogues, correspondence, legal expense, patents, traveling expense, salesmen's salaries, drawings, etc., are listed and the expense of each apportioned to each class of product in proportion to the benefit derived, the proportion being determined from inspection. Thus, it may appear that advertising expense should be distributed among four different products as follows: 10 per cent to the product A, 20 per cent to the product B, 30 per cent to the product C, and 40 per cent to the product D. Product A may be an old and staple article, having a general demand, while D may be a new and patented article for which demand must be created by advertising.

If the profit on any class of product is exceptionally high or low, it will call for a careful examination of the direct and prorated charges. The direct charges of stores and labor are very definite items and on these there can be little question. The indirect charges, especially those in connection with business administration and selling, are very intangible and hard to connect with any expense of manufacture, but it must be remembered that every dollar or expense, both direct and indirect, must be borne by the product which is made and sold.

The method of Hours by Cost Numbers for all shop expense and that of apportioning by inspection for selling and business administration expense, are most generally applicable to the ordinary manufacturing establishment.

DISCUSSION

William Kent, in a written discussion, described a seventh method of prorating overhead expense, namely a combination of

the first and second, prorating the expense in proportion to the sum of the material and labor costs.

For example, suppose that in a given time there are two products made, A and B, the first costing \$100 for material and \$50 for labor, the second \$50 for material and \$100 for labor, the overhead charges, or burden, for the two together being \$150. By the two methods of prorating given by Mr. Keely, (a) in proportion to the material, and (b) in proportion to labor, the cost accounts would show the following:

	A	B
By method (a)		
Material	\$100	\$ 50
Labor	50	100
Burden	100	50
Total factory cost	\$250	\$200
By method (b)		
Material	\$100	\$ 50
Labor	50	100
Burden	50	100
	\$200	\$250
By the combined method we would have		
Material	\$100	\$ 50
Labor	50	100
Burden	75	75
	\$225	\$225

Still another modification would be to charge material and credit burden with a certain percentage of the material cost, to cover storage and interest on capital invested in the material, and to apportion the remainder of the burden in proportion to the sum of the labor and of the material cost thus enhanced; thus, if 20 per cent is added to the cost of material, the account would stand

	A	B
Material	\$100	\$ 50
Add 20 per cent	20	10
Labor	50	100
Sum	\$170	\$160
Remainder of burden prorated	62	58
	\$232	\$218

Whether any of these methods, or the machine hour, or cost num-

ber method should be adopted in any particular plant depends on the nature of the business, and on the object that is to be obtained by the cost system.

Regarding the length of cast-iron pipe, assuming that it is only one of a hundred kinds of castings that the foundry makes, it is impossible to apportion precisely its share of the expense of supervision, taxes, insurance, depreciation, light, power, etc. Suppose the piece of pipe is not a regular product of the foundry, but only an occasional one ordered by a neighboring shop, the order being accepted at a very low price because the foundry is short of orders at the time. The book-keeper reports that money has been lost on that pipe, and presents the following account: Material, including waste, 1 cent per lb.; labor 0.5 cent; burden 1 cent; total 2.5 cents per lb. Sold for 2 cents; loss 0.5 cent. The owner says, "I think we have made money on that order, for the cost for labor and material was 1.5 cents, and the selling price 2 cents, leaves a margin of 0.5 cent to apply to burden. It cost nothing for selling and advertising, and the expense for supervision, taxes, etc. would have gone on if we had not taken the order." Six months later the order is repeated, when the foundry is full of profitable orders, and the price is made 3 cents, not because the cost including burden is 2.5 cents and 0.5 cent is wanted for profit, but because that is "the price the market will bear."

The following is a system of making an estimate of a machine-hour cost. Assume a large and expensive machine costing $2000, which is in use a different number of days each month. The cost-clerk may present the following tabulation of annual burden charges to be made against it:

	Cost while Idle	Additional Cost while Running
Interest, 5 per cent on $2000	$100	
Rent, 100 sq. ft. at 50 cents	50	
Taxes, 2 per cent on half value	20	
Insurance, 0.5 per cent on value	10	
Light and heat (in winter only)	20	
Depreciation (obsolescence and corrosion), 5 per cent	100	
Repairs or depreciation due to wear, 2 per cent		$40
Lubrication and cleaning, say		10
Power, 2 h.p., estimated load factor 0.25; 2 × 3000 hours × 0.25 × 2 cents per h.p-hr.		30

Superintendence, office expense, etc. Total $20,000, share of this machine, 0.5 per cent		100
	$300	$180
	180	
Total	$480	
Add for contingencies 25 per cent	120	
	$600 or $50 per month	

Charge $50 per month
2 per day if running 25 days per month
5 per day if running 10 days per month
10 per day if running 5 days per month
Labor costs $3 per day for each day the machine runs

Days run in a month	5	10	25
Labor cost at $3	$15	30	75
Machine hour cost	$50	50	50
Total	$65	80	125
Number of units of product made	50	100	250
Cost per unit	$1.30	0.80	0.50
Suppose these units are sold so as to net the factory 80 cents each			
Loss, each	0.50	0	—
Profit	—	—	0.30

Or suppose these units are parts of a finished product, shall they be billed to that product, 50 units at $1.30, 100 at 80 cents, 250 at 50 cents, plus the charge for material (whatever it may be), making it appear that the cost of the product varies from month to month according to the number of idle days of a certain machine during a preceding month?

A far better way is to have a fixed hourly charge for the machine in question, which is not changed during a whole year. For example, it may be estimated that the machine will be in use 150 days in the year, averaging $12\frac{1}{2}$ days per month. The daily charge then will be $50 \div 12\frac{1}{2} = \$4.00$, and if the work day is 10 hours, 40 cents per hour. The cost of these units will then appear as follows:

Days run in a month	5	10	25
Labor cost at $3	$15	30	75
Burden at $4	1820	40	100
Total	$35	70	175
Number of units made	50	100	250
Cost per unit	$0.70	0.70	0.70

This plan not only saves the book-keeper's time in figuring the hourly cost each month, but makes a fairer charge to the finished product of which these units are part, which product should not be charged with the accidental idleness of any one machine.

We can get the percentage of idle time directly for each machine by summing up from the time cards the number of hours credited to it in each year, or month if need be. Assuming that the machine should run 12½ days on an average to earn $50 per month, the table last given shows that we lost $30 on it the first month, $10 the second, and gained $50 the third.

I wish especially to emphasize the inadvisability of charging to a machine hour any part of the selling expenses, advertising, etc. The machine hour is part of the factory expense, and should not be charged with losses due to inefficient salesmanship. The sales department should be considered as a separate business from the factory, and should have a separate system of accounts.

Harrington Emerson said that cost records should not be given undue prominence as they are of value only when they foretell the future. Most modern cost accounting records the mistakes that have occurred but does not prevent future mistakes. Cost accounting to be of assistance must predetermine the standard cost of every item of material, of labor and of capital charge, and at the time the work is progressing check the actual against the standard.

Cost records are only one of many forms of efficiency records. A vast sum may be expended in some enterprise and the books recording the various transactions involved may balance to a cent; but this fact affords no indication of money that may be worse than wasted through inefficient materials, labor and equipment.

Standard costs of operation are not attained because in the first place the great majority of men are low in industrial efficiency. Beyond this, however, the standard is not attained because of the complexity of modern conditions, which introduces a dependent sequence, so that each is dependent upon that which follows. As a result, very slight inefficiencies grow in a dependent sequence into big inefficiencies in end results and very slight improvements in separate acts result in enormous gain. Because men are inefficient, single operations are inefficient, and through dependent sequence appalling wastes result. In every single operation, both for men and machines there may be (*a*) an over-

supply of hours or material; (*b*) a wasteful use of either; (*c*) too large a payment for the quality used; or (*d*) use of the wrong quality.

We may have ten men and ten machines and work for only six sets of them. The efficiency of supply will be only 60 per cent. One of these men may waste one-quarter of his time, but work with standard activity the other three-quarters, giving an efficiency of 75 per cent. The machine may have an efficiency of stroke of 80 per cent; of depth of cut, 50 per cent; of feed, 30 per cent; and of speed, 40 per cent, making the end efficiency of the machine only 4.8 per cent. The combined efficiency of use

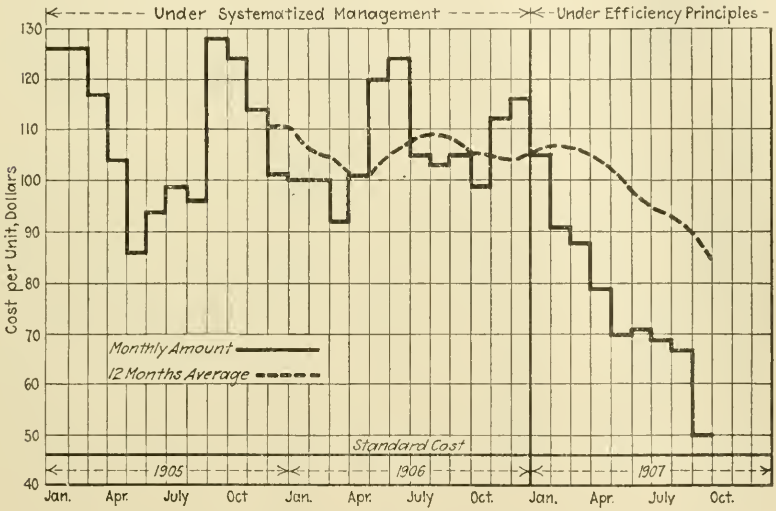

FIG. 1 DIAGRAM SHOWING DIFFERENCE IN ACTUAL COSTS ATTAINED IN WORKING WITHOUT STANDARDS AND WITH STANDARDS

of men and machines will be only 3.6 per cent, and the combined efficiency of use and supply only 2.16 per cent. The man and machine may be 20 per cent more expensive and both twice as good as they ought to be for the job, giving therefore an efficiency of assignment, 50 per cent; efficiency of price, 80 per cent; efficiency of supply, 75 per cent; efficiency of use, 3.6 per cent; and an end cost efficiency of only 1.08 per cent. This particular single operation as to labor charge and equipment rate is costing almost 100 times as much as it ought to.

In two diagrams the difference in actual costs attained in work-

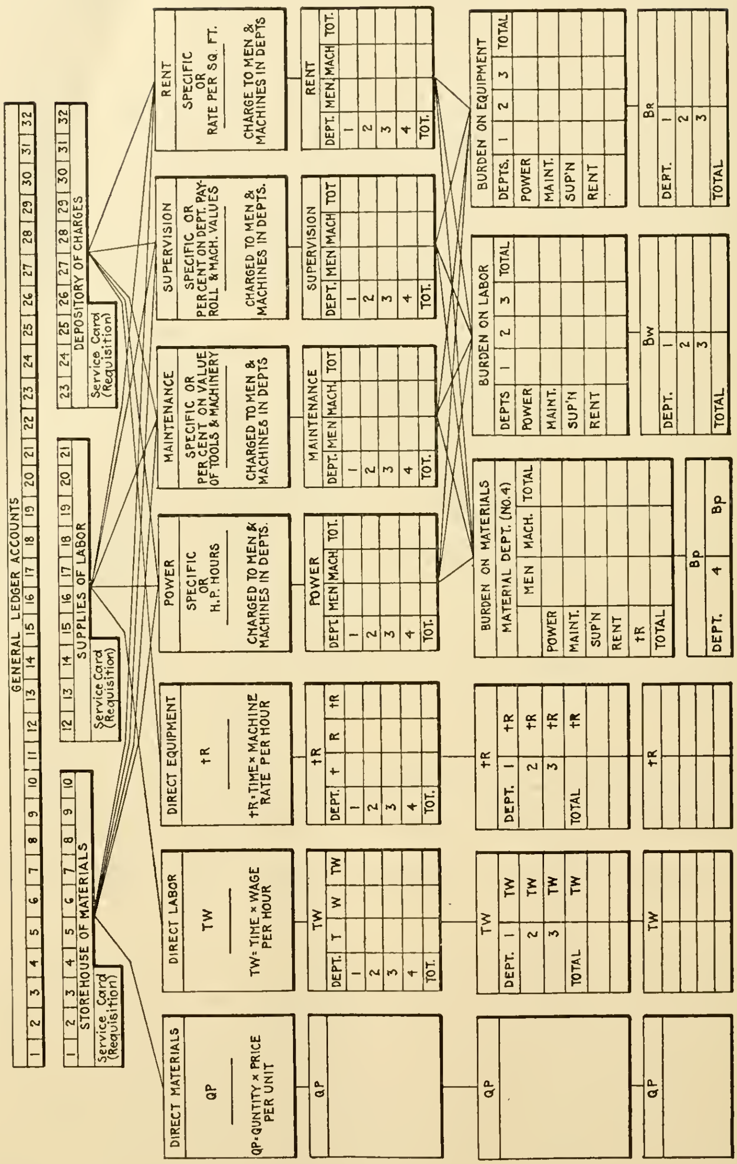

Fig. 2 General Plan for making Efficiency Statements and Conventional Method of using Records for Standard and Actual Cost Records

ing without standards and with standards was shown (Fig. 1) and a general plan for making efficiency statements and a conventional method of using efficiency records for standard and actual cost records (Fig. 2). This latter is so simple that it can be put on a 5 in. by 8 in. card, and may be used for recording anything from the cost of a hook and eye to the operations of all the railroads of the United States for ten years. The formula is made up of three parts, materials, labor, and equipment operation.

This record will show both standard and actual costs as to every item. Actual costs are standard costs with an inefficiency per cent added. This per cent is generally that of the previous month so that actual costs can always be predetermined. Any difference between predetermined costs and moneys spent is very slight and can be easily adjusted.

In the general discussion which followed Henry Hess said that knowledge of costs in every item was needed and that machine methods could not be substituted for individual personal management. Where a plant is too large for the supervision of one man, a number of men should coöperate in the management.

Both F. G. Coburn and Walter M. Kidder[1] emphasized the necessity for simplicity of method. Mr. Kidder thought that if it were borne in mind that the principle of overhead must be applied in proportion to the amount of production capacity consumed in the production of a given article, and a practical method that will approximate this result is sought, that a useful cost method would result. Carl G. Barth also disapproved of any method which required a complicated mass of figures.

J. F. Wickersham[2] described his experience with the New York Shipbuilding Company where a very detailed cost record was kept with satisfactory results.

Following a line of argument suggested by Mr. Barth, F. C. Andrews[3] said that the question of how much the selling price could be cut to allow a margin of profit was a most important one. In some plants it would take five or ten times the cost in clerical hire to keep track of the cost records, and selling from

[1] 127 West 56th Street, New York.

[2] Care New York Ship Building Company, Camden, N. J.

[3] Industrial Engineer, 1707 Arch St., Philadelphia, Pa.

the lowest list prices agreed upon by other manufacturers and with discounts is a satisfactory method.

A. C. Jackson described methods of distribution by the aid of lantern slides and Mr. Barth showed blueprints illustrating tables of costs.

The Author concluded the discussion by emphasizing the necessity of some basis for the distribution of costs. Simplicity was desirable, he considered, if it could be attained, but with a complicated product a complicated method of cost-keeping is necessary. The rule should be to use as simple a method as possible consistent with the results to be attained.

PORT FACILITIES FOR SHIPS AND CARGOS IN THE UNITED STATES

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Member of the Society

ABSTRACT OF PAPER

One of the most important of the controlling factors in marine transportation is the dispatch of vessels and cargos from one place to another. Therefore, any facility which will tend to increase the amount of cargo moved in a given time while a vessel is in port will increase the number of trips the vessel can make. To this end, port facilities must be provided for the unloading and loading of the cargos. They embrace the harbor, piers, railroads, floating harbor equipment and all the minor appliances, such as storage, rehandling and transfer facilities.

One of the fundamental differences between European and American ports is that nearly all of the former are at considerable distances from the sea, at the heads of navigation of rivers, while most of the latter are on the sea coast. This brings about an entirely different situation relative to the port facilities and therefore, it is not practicable to compare the port of Hamburg with the port of New York, and the methods and devices used in the one city are not at all adaptable to the other.

Another fundamental difference is brought about by the fact that the port of New York, while by far the largest of any in the world, is not the home port of any of the great trans-Atlantic steamship lines, and it is very plain that a company owning ships will make greater investments for port facilities at home than abroad.

Perhaps the greatest difference, however, is due to the extent to which lighterage is used at the port of New York. Manhattan Island is reached direct for freight purposes by only two of

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the many railroads that extend to the harbor front and access to Manhattan Island, Long Island, Staten Island and the adjacent waters is brought about by a very extensive system of harbor transportation known as lighterage, by which freight is moved at a minimum cost and with the greatest flexibility. A part of the equipment for this system consists of car floats, by means of which direct interchange of cars can be made between any of the railroads and access can be gained to freight terminals at any desired point on the waterfront. These car floats were originally designed for ferrying purposes, but it was soon discovered that they formed one of the most flexible devices for freight handling in and about a large marine terminal, and they must now be considered one of the most important features of the port of New York. In fact, so valuable are they to the railroads, that piers devoted exclusively to the loading and unloading of cars on floats have been taken over one after another along the lower part of Manhattan.

The principal difference to be noted between New York piers and those abroad is the absence on this side of heavy lifting machinery, which is always a prominent feature of the foreign ports. This has been brought about by the development of the lighterage business and more particularly by the adaptation of floating derricks for handling all heavy weights from lighters to ship's hold and from ships to lighters and then to the pier head or bulkhead for rail transportation or delivery in the city. This particular branch of transportation is an American feature and owes the extent of its development to the use for apparatus primarily designed and developed for wrecking purposes.

In the practice of this port, only the lighter portions of the cargos are handled over the ship's side on to the piers; that is, objects weighing a maximum of two tons, such as are readily handled by ship's winches and similar winches located on the pier. A fixed or traveling crane located on a pier can serve but one ship and often not more than a single hatch of that ship, while a floating derrick or lighter may move from ship to ship and from one part of the harbor to another and find much more constant occupation. It is also often found that the cost of handling freight over the ship's side from lighters is less than handling it across the pier, and it is the practice of the steamship companies to encourage the delivery of as large a quantity of goods as possible by lighter.

Consideration has been given to the matter of bringing the railroads and steamships close together, but wherever this has been tried it has been found impractical. Many piers are built with railroad tracks running down the center, but few cars will be found at any time on the piers. This is owing largely to the fact that a freight car is an awkward object to move about and that it contains a comparatively small quantity of goods; also, that the shifting and moving of the freight cars interfere with the work of handling material on the pier. Of course, this does not apply to goods that can be delivered by the carload, such as grain, coal and ores, for such materials do not come to the steamship piers referred to, but to special piers devoted entirely to their reception, where they are handled by machinery at as low a cost in this country as anywhere in the world.

The coaling of ships in the port of New York is of a somewhat unusual character, and to a certain extent affects the method of freight transfer. Coal is brought to the ship's side in canal boats approximately 20 ft. beam and capacity from 400 to 600 tons. To expedite the coaling it is done on both sides of the ship; that is, first on the off-shore side and then the ship is breasted out or moved some 20 ft. or 25 ft. from the pier and the coal boat moved in between the pier and the vessel and the bunkers filled on that side. It is apparent that cranes fixed on the pier during this time would have to extend some 25 ft. further, while the ship's winches, working in connection with a similar winch on shore, can transfer freight without interruption. These winches are designed to handle from one to two tons on a single line, and to be operated by the ship's crew and with whatever assistance is necessary from the shore.

It would seem that there is small probability of other mechanical appliances superseding this method in this port when freight is to be hoisted from a ship's hold. When freight can be delivered from a gangway at or below the pier level, mechanical devices to assist stevedores with handtrucks on grades have been found practical, and these devices are also much used to carry freight to and from lighters which bring a considerable amount of material to the piers for storage and trans-shipment to vessels.

No discussion of port facilities would be complete without some consideration of the matter of facilities for getting the freight to and from the steamship piers; that is, should the railroads deliver the material in cars on the piers or to the terminal

adjacent thereto, and to what extent and how should the railroads and waterfront be tied up together?

The Atlantic freight and passenger transportation at the port of New York has had its greatest development on the west side of Manhattan Island, and it is over this waterfront that it is necessary to transfer between ship and railroad and ship and factory vast quantities of merchandise. Owing to the fact of its isolation, it is reached directly by but a single railroad, and the situation has been aggravated by the fact that this shore front is connected with the terminals of railroads across the Hudson River by many passenger ferries.

As the Atlantic transportation business has grown, congestion along the waterfront has been steadily increasing. To meet this, the railroads terminating in Jersey City have adopted the practice of leasing the piers along the lower Manhattan waterfront and using them for the receipt and delivery of railroad freight which, of course, results in the exclusion of trans-Atlantic and coastwise commerce from these piers. This condition is looked upon with disfavor by the steamship lines and also by the dock department, which has at heart the best interests and most desirable use of the waterfront for marine transportation. It also results in great congestion of the piers and West Street from trucks bringing and removing freight.

An independent study of these conditions some time ago resulted in the Bush Terminal development at South Brooklyn, which is the most remarkable any city has ever seen. Investigation first developed the fact that the congestion and greatest avoidable waste in freight transportation in and about New York was due to the trucking. But the real principle involved is the fact that every considerable producer of merchandise has to ship goods not by one railroad or steamship line but by nearly every one, which necessitates his trucks visiting almost every day eight or ten different points for the delivery of one or two cases of goods to each. The impossibility of merchants and truckmen working together leads to endless confusion, congestion and delay at the points of shipment.

To obviate this condition, the Bush Terminal Company provided on the South Brooklyn waterfront float bridges where not only one but all the railroads could deliver freight cars to shore tracks, and a car-distributing yard on their own property, from which the cars could be delivered as required alongside factory

buildings so as entirely to eliminate not only trucking charges, but also unnecessary delays and confusion in shipping. The company also created a system of piers backed up by storage warehouses for the receipt and storage of raw material and also for the storage of finished material to be accumulated for shipments abroad. The result is the most perfect system of rail and marine freight handling, manufacturing and redistribution that has been accomplished to date anywhere in the world. All confusion and interference has been eliminated and congestion is unknown, and the general plan is being studied and copied in many parts of the United States.

The same arrangement applied to the Manhattan waterfront would bring about a satisfactory solution of the problem, if it were not for the congestion resulting from necessity of access of great numbers of people to the waterfront. It has been the people's contention that their safety is of the first importance, and that consequently no additional railroad facilities should be allowed upon that waterfront and even that those existing should be removed. To this end, the dock commissioner has prepared an elaborate plan for moving the railroad tracks from the surface to an elevated structure along the waterfront accessible to all railroads. This plan, however, involves an almost insurmountable difficulty in the grade to be overcome in raising the cars from the water level to from 25 ft. to 30 ft. above, and the additional expense of supporting freight cars and locomotives upon an elevated structure.

Primarily, it would seem that the object to be attained is the separation of the passenger and freight transportation, and it would appear that this could be brought about at much less expense by elevating the passenger traffic at and along the waterfront; that is, by treating the Manhattan waterfront exactly as the Brooklyn waterfront, and then, for the passenger traffic which must be provided for, create an elevated street or highway adjacent to and along the front of the piers on West Street to be used exclusively for foot passengers and vehicles for passenger transportation, to be reached at various points which might be every third or fourth block, by ramps of a grade such as to be unobjectionable to foot passengers and vehicles.

It would then be possible to give all the railroads free access with cars to West Street and eliminate all danger to foot passengers. The railroad and terminal companies could then take up

and develop the property on West Street, and the cars would be run from West Street directly into these terminals for loading and the car floats would disappear from the waterfront except at the float bridges. By this modification, it would also be possible to distribute the car float bridges along the waterfront, which it is believed would be more practical than to have them all at one point.

DISCUSSION

H. McL. Harding[1] in a written discussion gave a detailed description of the various methods now in vogue for the mechanical handling of freight to and from vessels at ports both in the United States and abroad, including the gantry crane, the ship's winch and the transfer hoist.

At the foreign ports equipped with transferring mechanism for miscellaneous cargos, the gantry crane is everywhere in evidence, not only in Germany, England and France, but also in Japan and at the South American ports. The rapidity attained by this crane within its limited range is remarkable, and this is regarded as of more importance than economy of labor. There has been discharged from the ship's hold upon the piers by one electric crane 134 tons of miscellaneous freight per hour. This embraces about 45 to 60 cycles per hour with loads varying from 1 to 3 tons for the following cycle: hoisting, 40 ft.; swinging, 150 ft.; lowering, 20 ft.; and then hoisting, swinging back and lowering the hook to the starting point.

In one example the total working expenses for 400 tons discharged by electric cranes, with current at 5 cents per kw-hr. and including interest upon capital, depreciation, operators' wages, lubrication, etc., amounted to less than 2 cents per ton, discharging from the hold of a vessel and delivered upon the pier. It will be seen that at an expense of 2 cents per kw-hr. for electric current, the cost would be not over 1¾ cents per ton. Mr. Broughton states in the London Electrician that with electricity at 2 cents per h.p-hr. the total expense of the crane work in discharging 1000 tons of general cargo with cranes of 3 tons capacity was about $4.13, or less than ½ cent per ton. This is on the basis of lifting the load 30 ft., slewing 100 deg., lowering 30 ft.

In order to get the best performance in hoisting, there should

[1] Consulting Engineer, 17 Battery Place, New York.

be rapid acceleration, uniform motion at high-speed and quick retardation. There is excellent economy attained in rapidity and economy in the operation of the gantry crane. Its limiting factor is its range of operation, being able to serve only a semicircle of a diameter usually not in excess of 40 ft., or perhaps limited to a quadrant of a circle of this diameter.

By suitably arranging the jibs of the cranes, three gantry cranes can simultaneously lift the cargo, which has been raised out of a ship's hold by the ship's cranes, from the deck or from an extended platform, or even from the side of the piers, or in the usual way of burtoning. On projecting piers, as along the New York waterfront, averaging 125 ft. in width, if a gantry on each side takes up 40 ft. there would be room only for a shed 45 ft. in width. To obviate this difficulty, long jib gantries are placed upon the roof, as at Bristol and Liverpool. These, however, do not serve the interior of the sheds advantageously.

In the United States, as Mr. Donnelly has stated, the ship's winch is almost exclusively used for miscellaneous cargos, although on many coastwise ships, the winch is supplemented by trucking through the side ports from between decks when the tide is favorable. Even when the side ports are used, the winch is employed for cargo from the lower hold, although in some cases the winch is used to raise from the lower hold to between decks, and the load then swung clear of the hatchway and hand-trucked through the side ports. Advocates of the winch state that it is cheaper than trucking through the side ports, and figures seem to substantiate this, but the advantage of trucking through the side port is that there is less congestion than when the winch is the exclusive method.

The weak point of the ship's winch is congestion on the side of the pier, even when the draft is burtoned or when there is an inclined gang-plank. It may be said that there is even more congestion when the plank is used, though it increases the distance from the edge of the pier where the draft can be placed. The drafts are deposited in the little space upon the side of the pier opposite the hatch which is being unloaded, which is about 7 to 8 ft. long and about 7 ft. wide. An individual draft will average less than two boxes, though it may comprise six boxes, varying from one to six marks or cross-marks, and provision must be made for all conditions or circumstances. There are sometimes three winches working at the same hatch; and the weights of the

individual drafts and the number per hour would compare favorably with the operation of the gantry crane, were it not for the congestion produced on the side of the pier due to the area being so limited, and for the necessity for distribution according to the number of shipping marks and cross-marks. There are about 40 drafts per hour with an average load of 1½ tons. This congestion prevents a discharging capacity equal to that of the gantry cranes.

The cost per ton of swinging upon the side of the pier by the winch is about 3 cents. The second movement, including distributing to the various portions of the piers, assorting and tiering, averages about 30 cents per ton; this includes very little tiering, only to about the usual height of 5 ft.

It will be noticed that neither the ship's winch nor the gantry crane, either separately or combined, fulfils the conclusion of the Association of Navigation Congresses at its Philadelphia meeting in May 1912, to the effect that "all the terminal area must be served mechanically," that is, that every cubic foot (not square foot only) within the terminal area must be served by machinery so as to avoid rehandling, and that there must be continuous rapidity.

Mr. Harding then referred to the third method of freight handling now being adopted along the German rivers, which may be called the transfer hoist. This consists of a tractor, suspended from an overhead track, and three trailers or more drawn by it, forming a train. Each trailer consists of a hoist suspended from wheels engaging the overhead track. The tractor and hoists are all controlled by a transfer man in a closed cab. There are in general fixed side tracks and movable cross tracks. The movable tracks are supported from a traveling crane, either of the shop or gantry type, and are either between the fixed side tracks of the shop crane, or in the form of a loop when supported from the gantry crane.

By means of this arrangement of fixed and movable tracks all cubical area can be served the same as with a shop crane, but with the addition of continuous rapidity. These transfer-hoist trains, moving along suitably planned fixed and movable tracks, in combination with the ship's winch or with the traveling gantry along broad quay walls, or even in combination with the so-called "cargo hoists," will enable the conclusion of the Navigation Congress to be satisfactorily fulfilled. The ship's winches will

hoist from the hold through the hatchways above the ship's deck, and from there the transfer hoist by burtoning will convey and lower to any part of the terminal, traveling suspended from the overhead tracks. Provision is made for distribution and assorting, each hoist generally conveying only one consignment.

For the transference of miscellaneous cargos, the gantry crane, though possessing great rapidity and economy of operation, is not suitable for narrow projecting piers on account of the room necessarily occupied if located upon the pier floor; if upon the roof, it does not serve the interior of the shed satisfactorily, while for the larger ships, its reach is not sufficient to serve the holds; this is especially true when they are breasted out 20 ft. or more. Its range, though much greater than the winch, does not serve sufficient terminal area. For cargos of but few shipping marks, of the smaller ships berthed along quay walls with car tracks under or adjacent to the gantry crane, the results are excellent, though its range of service is still limited.

The ship's winch is economical and rapid in operation, but its range is exceedingly small and its rapidity of operation is limited by the congestion occurring at the place of depositing. In combination with other appliances, as described, its rapidity is increased and the congestion removed.

The transfer hoist in trains, with fixed and movable overhead tracks in combination with the ship's winch or with the gantry crane gives rapidity, economy, and the serving of the whole terminal area, and also provides for distributing and assorting.

Harry Sawyer [1] took up the question of congestion in the streets. He said there were various ways of overcoming it: by reducing the amount of freight handled, by distributing it over longer periods of time, by distributing it over greater area, and by handling it at a higher rate of speed.

The first was certainly not the solution as the quantity of freight handled could not be reduced, but more and more freight had to be handled all the time. Of the remaining methods the distribution over longer periods of time could be obtained if transportation companies would take freight from the shipper's place of business and deliver it to the consignee as express companies do. Motor trucks could make regular trips through the city delivering and collecting freight. This would reduce cost as well

[1] Consulting Engineer, Shaw Electric Crane Co., Muskegon, Mich.

as save congestion of streets for fewer trucks would be required and they would go loaded both ways. A great amount of travel with small or no load would be saved.

The means of saving congestion by distributing the work over a greater area could be made very effective. A series of local freight stations should be provided with a railway system for local distribution. With such a system long hauls to and from steamship piers would be avoided. The short hauls to the nearest local station would save both in expense and street congestion.

Mechanical appliances for handling freight rapidly to and from drays and in sheds should materially reduce congestion.

As to the question of two levels it seemed entirely practical, and the economy of space was of sufficient importance fully to justify it, but the best division of work between the two levels might be an open question. Railway cars, drays, and passenger traffic, both foot and carriage, must be considered. A separation of grades was desirable and with two grades for three classes of traffic it seemed better to combine dray and passenger traffic on one level than to combine either one with railway traffic. If passenger traffic alone was to pass over the second floor the force of Mr. Donnelly's argument that only a light structure would be required could be conceded, but this arrangement would not accomplish the desired result, as there would be railway cars, street trucks, and foot passengers all on grade, for it was not possible to exclude foot passengers where trucks were allowed. There were several advantages in elevating the railway tracks. Grade crossings would be eliminated. With suitable freight handling facilities, the freight could be unloaded from steamer to the second floor of the pier shed fully as cheaply as it could be unloaded to the first floor. If the chain of local freight stations and the distributing railway were installed most of the freight would come to and leave the pier by rail and would be handled on the second floor level without interruption or interference by truck and passenger traffic which would have exclusive use of the grade level. It had become the established practice where traffic demanded separation grades to put steam railways either overhead or underground, reserving the street level for truck and passenger traffic, and it was a question if this practice could be reversed in the case of the New York waterfront.

Elias Cahn [1] agreed with Mr. Sawyer in regard to the relative

[1] Dock Department, Pier A, North River, New York.

cost of the railroad tracks on the grade and an upper level. If the street was to be 250 ft. wide, as it would have to be to provide for wagon and vehicular traffic as well as foot passengers, at least 50 ft. of this roadway would be needed for railway trains, which would make the cost very great; if the cost of the ramps leading up from the street to the elevated structure were added to this, the expense would be even greater. The ramps would require about a 5 per cent grade, necessitating a length of about 500 ft. Immediate adoption of this plan would be impossible, as many of the piers had only one floor, and the railroad companies would not adopt this system immediately. In the meantime the city would suffer damages.

The provision of an elevated roadway meant practically raising the street, and all the buildings alongside the street would suffer damages in consequence of the changes required to adapt them to the new scheme. If the former were adopted, every one of the single-story piers would have to be changed to a two-story structure, and all the houses alongside the street would have to be changed accordingly. The property in the street where the ramp was located would likewise suffer damages, and the cost would be absolutely prohibitive. An elevated freight railroad therefore appeared preferable to an elevated street.

Geo. A. Orrok presented some figures for the cost of handling coal on a pier which was properly designed for the purpose. Some twenty years ago when he first commenced to study the coal-handling business, it was thought very satisfactory if coal could be removed from a ship for anywhere from 25 to 30 cents per ton. When this cost was reduced to 14 cents a ton it was thought remarkably low indeed; it was only a few years since it reached as low as 7 cents a ton. Today, coal in bulk, both at the big power stations and at the big receiving points, was being taken out of ships and barges at an expense not exceeding 2 cents a ton where trimming could be left out of the question. Most of the ships used for the transporting of coal were self-trimming ships.

Mr. Orrok did not think, however, that package freight could be handled from vessels by machinery. If there were, as very frequently happened in a steamer, 4000 to 5000 packages of freight of all sizes, from a few pounds up to 15 tons in weight, each of the packages probably addressed to different persons

scattered over at least three-quarters of the United States, they could not be put in the same freight car, but had to be separated on the pier. Under these conditions it looked as if the present way of handling it was about the best way. Handling packages by machinery took a good deal of time and money: the men had to be paid to do the work, and at the same time the machinery had to be kept up. A man with a two-wheel truck could do the work just as well, in most cases at less cost.

Mr. Harding replied that it did not appear to be economical when the weight of the package was small, say 25 lb., but the average of the consignments was very much greater. On one pier in New York City the weight of the average consignment that came across the bulkhead was about 750 lb., while at another in Providence, it was 1000 lb., and on the steamships it was about 1200 lb., varying according to whether it was in the coastwise service or a trans-Atlantic liner.

W. C. Brinton [1] said that practically all the equipment and devices described by Messrs. Harding and Donnelly had to be installed at the time a pier shed was built. It was not usually feasible to place overhead equipment in the type of pier sheds or warehouses existing today. The head room in most of them was not sufficient to permit the economical operation of an overhead system. Though it might be possible physically to install an overhead system in existing types, the room available between the bottom of the carriers and the floor would be so small that there would not be sufficient height for tiering goods.

The overhead systems of telpherage and transferage might possibly be developed in the future so that it would be advantageous to install these systems for certain classes of work when entirely new piers or warehouses were being built. Looking ahead a few years, the overhead system would first become a definite success on specially constructed piers which handled only cargos of a single commodity or cargos containing but a few different lots and thus requiring but little sorting.

He stated that there was in this country today an investment of several billion dollars in piers on which the overhead system could not be applied in such a manner as would give a fair financial return on the investment. Pier owners could not afford to

[1] Bush Terminal Company, Brooklyn, N. Y.

tear down their old pier sheds and build new ones in order to get the head room required by any transferage system.

Storage battery trucks were the most feasible means for immediate improvement with existing piers and warehouses. There were a great many plants in which storage battery trucks could make a direct money saving as compared with the cost of hand trucking. One of the chief advantages of the storage battery truck consisted in its ability to do the same work in less time than was required by hand trucking. The freight handling capacity of existing piers could be increased by the electric truck, and ships would not need to be detained in port as long a time as was now required.

Weather and other conditions beyond human control made it impossible to have freight steamers arrive on any regular schedule. The result followed that the work on most piers was either a feast or a famine. For rapidly fluctuating volumes of work there was a great advantage in having machinery which was completely self-contained and which could be instantly moved from pier to pier wherever the work might be.

He thought that engineers had not yet fully developed the possibilities of electric machinery driven from flexible cable plugged in at any convenient socket on piers completely wired with power circuits. Storage battery cranes and dock trucks were but in their infancy. Considering the great investment required for new and higher pier sheds, and the investment in overhead trackage which on the average pier must occasionally remain entirely idle, the most promising means for immediate improvement lay in machinery operated on the floor level and driven from flexible cable or from storage batteries.

BOSTON MEETINGS

At the meeting of the Society in Boston on February 25, the principal paper, Some Thermal Properties of Concrete, was presented by Prof. C. L. Norton, Mem.Am.Soc.M.E. This was followed by a brief paper on Experience with Concrete in Fires, by G. E. Fisher, engineer of the Arkwright Mutual Fire Insurance Companies. On March 25 Frank W. Reynolds, Mem.Am. Soc.M.E., presented the main paper of the meeting, The Modern Cotton Mill. This was followed by short papers on Lighting of Mills, by Albert Pearson, Mem.Am.Soc.M.E., and Air Conditioning for Textile Mills, by Frederick W. Parks, president of the G. M. Parks Company, Fitchburg, Mass.

Abstracts of the papers, together with the discussion presented at each meeting, are given herewith. The complete reports are on file in the rooms of the Society.

SOME THERMAL PROPERTIES OF CONCRETE

By Charles L. Norton, Boston, Mass.

Member of the Society

Since December 1907 a series of experiments has been carried on in the laboratory of heat measurements of the Massachusetts Institute of Technology, having for its object the study of those physical properties of portland cement concrete which affect its value as a fire resistant material. While these researches are not complete, it is perhaps of interest at this time to discuss some of the results obtained.

It was proposed at the outset to make a study of the various physical properties of portland cement concrete over as wide a range of temperatures as possible, and among the properties were the following:

a Coefficient of linear expansion

The American Society of Mechanical Engineers, 29 West 39th Street, New York.

b Diminution of mechanical strength after heating
c Specific heat
d Coefficient of thermal conductivity

A comparison with other materials was also planned.

COEFFICIENT OF LINEAR EXPANSION

The measurements of the coefficient of linear expansion are now practically completed. The method adopted for the measurements of elongation caused by heating was the common so-called telescope method. The specimens in the shape of 6-in. or 10-in. cubes were slowly heated in a double gas muffle or an electric resistance furnace. The temperature of the furnace and of a number of points in the concrete was taken by means of platinum-rhodium couples. Near the furnace were mounted two telescopes, which could be sighted through holes in the furnace wall upon reference points on the surface of the block. At low temperatures an arc light and system of mirrors were used to furnish adequate illumination. One of the telescopes was provided with a micrometer eye-piece by means of which a movement of the reference mark of 0.0001 in. could be measured.

The values obtained at low temperatures agree very well with the commonly accepted value of 0.0000055 for the elongation per unit of length per deg. fahr. Apparently this value increases slightly up to 575 deg. fahr. Above this point the coefficient becomes smaller: at 1,500 deg. fahr. the coefficient becomes zero, and above this point, slightly negative.

Table 1 gives the average values for a large number of specimens:

TABLE 1 AVERAGE VALUE OF SPECIMENS

Temperature, Deg. Fahr.	β in the Expression $l_t = l_o\ (1+\beta t)$
72 to 360	0.0000045 to 0.000060
72 to 750	0.0000050 to 0.000060
72 to 1090	0.0000045 to 0.000050
72 to 1600	0.0000035 to 0.000042

The blocks which had been heated to 1,500 deg. did not return to their original dimension on cooling, their permanent elongation being about 75 per cent of their maximum elongation. There was no sensible permanent elongation resulting from a second heating.

All of the specimens tested for expansion were of stone concrete of the proportions 1: 2: 5. The stone was clean, the sand sharp, the cement of good quality, and every precaution was

taken to secure a concrete of the first order. The specimens weighed on the average 150 lb. per cu. ft. A considerable number of tests demonstrated that the dimension which these small cubes took during a rise in temperature was dependent upon the temperature of the outside rather than the average temperature of the block.

The variation of this coefficient with the temperature is such as to make the difference between it and the coefficient for steel considerable at high temperatures. As has been well understood, the similarity of the coefficient is helpful in preserving the integrity of reinforced concrete structures at ordinary temperatures, but the divergence of the two coefficients at higher temperatures is not a serious matter in the reinforced structure when exposed to fire, since the metal reinforcement and the concrete surface are rarely at the same temperature.

There is a marked expansion increase up to about 700 deg. fahr. followed by a slower rate, and at about 1500 deg. fahr. by marked shrinkage.

COMPARISON WITH CLAY BRICK AND SILICA BRICK

	Clay Brick	Silica Brick
Temperature Range, Deg. Fahr.	Coefficient of Expansion (β)	
0 to 900	0.0000038	0.000012
0 to 1600	0.0000031	0.000008
0 to 1900	0.0000023	0.000007

Some bricks and all concrete are liable to a permanent set of about 75 per cent of their total elongation on heating to 1500 deg. fahr.

DIMINUTION OF MECHANICAL STRENGTH AFTER HEATING

In order to study the effect of high temperatures upon the compressive strength of concrete several scores of 6-in. and 8-in. cubes were made and allowed to set for 90 days or slightly longer. These blocks were heated at different temperatures in a gas furnace similar to that used for the expansion experiments, for different lengths of time at various periods from the 90 days up to five years.

The cubes which were not heated showed an average compressive strength of 2700 lb. per sq. in. when 90 days old; at the end of five years the compressive strength of the blocks had risen to an average value of 4278 lb. per sq. in. When aged for 90 days *in a damp place*, exposed to fire at 900 deg. fahr. for two hours,

the compressive strength fell to 2200 lb., or a loss of 15 per cent. Blocks five years old, dry, exposed to fire at 1700 deg. fahr. for two hours, gave values of 1500 to 1900 lb. per sq. in., a loss of 50 per cent to 65 per cent.

The loss was much more marked in the case of the 6-in. than the 8-in. cubes. It is evident that the small cubes give far too great loss in strength on heating. Some cubes allowed to stand lost much by slacking; this action has been noted by Professor Woolson in earlier tests. It should be noted also that there was a considerably greater deformation under load of the heated blocks than of those not heated.

A large number of small beams were next made, some with and some without reinforcement; most of these were either 6 in. by 6 in. by 48 in. or 8 in. by 8 in. by 48 in. The specimens which were reinforced contained four ½-in. round steel rods situated near the corners equidistant from the two faces of the beam. In some the distance from the reinforcement to the face of the beam was 1 in. and in others 1½ in. A few beams had a 2-in. protection to the reinforcement.

Three beams for example, each 6 in. by 6 in. by 48 in., in which the reinforcing rods were 1 in. from the face of the beams, were broken by center load, the first beam not having been heated at all, the second heated for one hour in a fire that fused the surface of the concrete, and the third being similarly heated for two hours. The beam which was not heated broke under a load of 5700 lb., the second, heated for one hour, broke at 2750 lb., while the third, heated for two hours, broke at 1950 lb. This is a most remarkable showing under severe conditions. It should be borne in mind that these small beams were so slow in cooling down that they showed the effect of heating much longer than the time mentioned, say 24 hours. The flames, moreover, surrounded the beams on all sides. In tests at three and five year ages, the temperature was between 1600 deg. and 1700 deg. fahr.; the 8 in. by 8 in. by 48 in. reinforced beams broke at 14,200 lb. when not heated, but at 4920 lb. when heated. Smaller beams 6 in. by 6 in. by 48 in., not reinforced, broke at 1300 lb. when not heated, at less than 100 lb. heated.

As a result of these tests upon the beams, it was evident that the failure of the specimens was in every case due to the rods pulling through the concrete. This is wholly a matter of insufficient anchorage, and these short beams are therefore not very

helpful in giving information concerning the behavior of full-sized beams in buildings, and except as they give relative information concerning different mixtures, they are of very little value. The small cross-section of these beams tends to make the fire exposure abnormally high. It should be noted that all of the non-reinforced beams broke in handling, which suggests the severity of the tests as compared with the experience of actual conflagrations.

A series of similar beams was next made up of cinder concrete, the proportions of the mixture being 1 : 2 : 5. A portion of these were mixed with clean cinders, which showed upon analysis but little carbon; a second part was mixed with cinders to which 10 per cent of fine bituminous coal had been added and the other beams were mixed with cinder, to which had been added 25 per cent of fine coal. The 25 per cent mixture can be disposed of in a word—when once thoroughly heated it burned until it fell to pieces. With the 10 per cent mixture, however, no such action occurred; there was no indication that the concrete would support its own combustion even for a short time. It was apparent, however, that the 10 per cent mixture was not so good a fire-resistive material as that which contained no added carbon. From the few specimens containing less than 10 per cent which have been examined up to the present, it seems probable that the safe limit is close to 5 per cent. More information is now being secured on this point by the use of larger beams.

SPECIFIC HEAT

The study of the specific heat of concrete was made by the ordinary calorimeter method, the "method of mixtures" of Regnault. Specimens of the concrete, usually fragments of the larger test pieces, were heated slowly in an electric resistance furnace to the desired temperature and then plunged into the calorimeter. The weight of the water and its rise in temperature give the amount of heat given off by the body in cooling. Extraordinary precautions were taken in getting the exact average temperature of the specimen in the furnace, and to insure its rapid transfer to the calorimeter. In most of the experiments a double calorimeter was used so that the specimen did not come in contact with the water of the calorimeter, so that any evolution of heat by hydration of the cement was avoided. Tables 2 and 3 give the specific heat of concrete and of other materials.

TABLE 2 SPECIFIC HEAT

Temperature, Deg. Fahr.	Stone Concrete 1—2—5	Stone Concrete 1—2—4	Cinder Concrete 1—2—4
72 to 212	0.156	0.154	.....
72 to 372	0.192	0.190	0.180
72 to 1172	0.201	0.210	0.206
72 to 1472	0.219	0.214	0.218

TABLE 3 SPECIFIC HEAT OF OTHER MATERIALS

Material	Temperature	Specific Heat
Stone Concrete	72 to 500	0.210
Stone Concrete	72 to 800	0.204
Stone Concrete	72 to 212	0.180
Cinder Concrete	72 to 212	0.156
Red Brick	72 to 212	0.214
Red Brick	72 to 500	0.192
Red Brick	72 to 1100	0.200
Quartz	400 to 1200	0.308
		0.305
		0.279
Cement	room temperature	0.271
		0.186
Sand		0.191
Trap		0.201
	?	0.258
		0.270
Sandstone	?	0.220
Dolomites		0.222
Slag		0.169
Granite	?	0.173
		0.196
		0.200

COEFFICIENT OF THERMAL CONDUCTIVITY

The measurements of thermal conductivity were made by a number of methods and have taken far more time and energy than all the others put together. The thermal conductivity is that property which determines how rapidly heat will travel through a substance and how rapidly therefore objects beyond will be heated by transmission. The conductivity becomes of prime importance in all questions of protection of the metal in reinforced concrete buildings. There is a limited amount of data to be found relative to this important property of any of the

common materials of engineering and such data as are to be found are not concordant. As to the conductivity of concrete or its variation with temperature and with composition, practically nothing has been known.

The methods adopted for the measurements will be here described in outline only. The formula showing the relation of the temperature upon the two sides of a plate to the amount of heat which would flow through it is as follows:

$$Q = \frac{K(t_1 - t_2)\, sA}{d}$$

$$\text{or} \quad K = \frac{Qd}{(t_1 - t_2)As}$$

where

K = the coefficient of thermal conductivity dependent upon the nature of the material and its temperature
Q = the quantity of heat flowing through the plate in the area measured
A = the area
t_1 = the temperature of the hotter side of the plate
t_2 = the temperature of the cooler side of the plate
d = the thickness of the plate
s = time during which Q units flow through the area A.

The formula will be seen to be merely an expression of the following relations, that the flow of heat is proportional to the area, to the temperature and to the time, and that it is inversely proportional to the thickness.

After spending many months in attempting to develop other methods, the electrical method used by the writer for the past 15 years in studying the flow of heat through steam pipe coverings was adopted. The value Q of the heat flowing was determined by supplying the heat by means of the heating of a conductor carrying a current of electricity; by measuring the electrical energy supplied the quantity of heat developed may be known with great precision. Further, if this heat is passed through the plate under test and into a calorimeter on the far side, a check upon the value of Q may be had. For the determination of the temperature difference, thermal couples, resistance thermometers, and mercury thermometers were used, but thermal junctions made of thin strips of copper and nickel, or of platinum and platinum-rhodium, were generally found most serviceable.

The apparatus used for the lower temperatures consisted of a thin, electrically-heated plate, to the two sides and edges of which concrete could be applied. Outside of the concrete there were then placed heavy copper or brass plates which could be kept at a constant temperature by an internal circulation of water. Thermal junctions were placed at several points on each surface and in the body of each concrete plate. The electrical input was measured by calibrated Weston instruments, and calibrated thermal junctions gave the value of the temperature difference to the nearest one-one hundredth of a degree. For the thickness, numerous measurements were made with a pair of flat-nosed calipers and averaged. It was necessary to keep this apparatus running for several days before it could be balanced, that is, before the rate of flow of heat outward through the plates became constant and equal to the electrical input.

Later, in order to make tests on plates as thick as some of the walls in common use, another method was adopted. Cubical boxes 36 in. in outside dimension were built with walls of several thicknesses. Inside the boxes were placed electric heaters which served to raise the inside surface to a temperature above that of the surroundings and a small fan served to keep the air in the box stirred to insure uniformity of temperature throughout. The boxes were tightly sealed. The power supplied to both heater and fan was measured as before. Mercury thermometers and thermal junctions, as well as a Callender recording resistance thermometer, were used to measure the difference in the temperatures inside and outside of the box.

Data have been secured on scores of specimens and they are practically identical with the results obtained by the plate tester. It must be borne in mind that the thermal conductivity is based upon the difference in temperature at some two points in the material itself and not the difference in the temperature of the air on the two sides of the specimen. If, for instance, a 6-in. wall of solid stone concrete separates two spaces whose temperatures are 40 deg. fahr. apart, the surface temperatures of the concrete will be much nearer one another than 40 deg. fahr. There is a drop in temperature in passing through the wall which is dependent upon the thermal conductivity and upon the quantity of heat passing through. There is a drop in temperature at the surface which is dependent on a rather complex set of relations between the temperature and nature of the surface

and the surroundings, and the adjacent air. For many materials the amount of heat lost from a surface for small differences in temperature not over 20 deg. fahr. is between 16 and 18 B.t.u. per sq. ft. per 24 hours for 1 deg. difference between the surface and the average temperature of the surroundings. More than one-half of this is a loss by radiation in accordance with the Stephan-Boltzman law.

$$\text{Energy} = \text{Constant } (T^4 - T^4_o)$$

$$W = 5.7\ E\left[\left(\frac{T}{1000}\right)^4 - \left(\frac{T_o}{1000}\right)^4\right]$$

where

W = watts

T = absolute temperature of surface

T_o = absolute temperature of surroundings

E = about 0.6 to 0.7 (always less than 1)

For the high temperatures a modification of the entire process was found necessary. The concrete to be tested was cast in the form of a cylinder on the outer surface of and concentric with a steel bar which could be heated to a high temperature by the passage of a heavy current. Outside of the cylinder of concrete was applied a closely fitting "continuous" calorimeter. The temperatures of the bar and of the calorimeter were measured by thermal junctions, and the amount of water and its rise in temperature gave the value of Q. In order to guard against the uncertainty of the temperature at the ends of the bar, the calorimeter was made so as to enclose only about one-half the length of the bar, the rest being covered by guard rings similar to the calorimeter, but without provision for the measurement of the quantity of water.

The heating of the bars required a considerable amount of special apparatus, since it was necessary to provide a current of upwards of 2000 amperes for the high temperatures, and to be able to vary its amount to any desired value below that point. For this purpose there were installed three 15-kw. transformers connected on the primary side with a three-phase 2300-volt circuit. By means of divided secondaries and a rather elaborate arrangement of switches, the secondary voltage could be varied from 190 volts down to 55 volts. This secondary voltage was applied to the primary of a second step-down transformer, whose secondary was divided into 20 coils. By means of a switchboard the entire output of the transformer could be had at almost any

desired low voltage. This enabled us to heat bars insulated by materials of different composition and of different thicknesses to any desired temperature up to 2800 deg. fahr. With this arrangement both the steel and the concrete can be easily melted.

The results obtained are given in Table 4. It is to be regretted that there is no uniformity of practice as to the units to be adopted in reporting the measure of effectiveness of insulators. While the physicist renders his report in calories per square centimeter, per centimeter thickness, per one degree centigrade per second, the steam engineer confines his observations to B.t.u. per hour, per square foot, per inch of thickness, per one degree fahrenheit, and the refrigerating engineer reports on the basis of a 24-hour time unit. The writer has even seen a report in

TABLE 4 COEFFICIENT OF THERMAL CONDUCTIVITY OF CONCRETE

Temperature of Hot Side of Plate		Mixture	Coefficient, Cal. per 1° C. per sq. cm. per cm. per sec.	Coefficient, B.t.u. per 1° F. per sq. ft. per in. thick per 24 hours
Deg. Cent.	Deg. Fahr.			
35	95	Stone 1—2—5	0.00216	150
50	122	Stone 1—2—4 not tamped	0.00110 to .00160	76. to 114.
50	122	Cinder 1—2—4	0.00081	56.
200	392	Stone 1—2—4	0.0021	146.
400	752	Stone 1—2—4	0.0022	153.
500	932	Stone 1—2—4	0.0023	160.
1000	1832	Stone 1—2—4	0.0027	188.
1100	2012	Stone 1—2—4	0.0029	202.

terms of hogsheads of water raised to the boiling point, time not stated. A brief comparison of these values with those for other materials may be interesting.

The specific heat of concrete is slightly less than that of either red brick or fire brick, hence the amount of heat needed to raise the temperature of a pound of brick is about 10 per cent more than for a pound of concrete. But the density of concrete is enough greater than that of brick to raise the heat capacity of a cubic foot of concrete above that of brick. The difference is not large, however.

It seems clear that for a time after the beginning of exposure to fire, the concrete and its reinforcement will expand at much the same rate, but that the further expansion of the surface will

not proceed at so rapid a rate. This will tend to reduce the stresses which the expansion of the heated surface would otherwise set up in the cooler interior. It is perhaps because of the failure of the concrete to return to its original dimensions that the small amount of surface cracking found after a fire is due.

The experiments made with coal and cinder mixtures indicate the necessity of added care in the selection of cinders for this purpose.

Table 4 of thermal conductivities gives data as to the rate at which heat will travel through concrete. It is interesting to note the great difference between the tamped and the untamped con-

TABLE 5 THERMAL CONDUCTIVITIES

Material	B.t.u. per 24 Hours per 1 Deg. Fahr. Sq. Ft. per 1 In. Thick
Agglomerated Cork	6.4 to 9.0
Linings or Quilts of Hair and Flax	10.0 to 18.0
Pine	13.0
Oak	26.0
Spruce	14.0 to 18.0
Magnesia	10.0
Asbestos Sponge	8.0

cretes made from stone. The one was as porous as possible, and the other as dense. One transmits nearly twice as much heat as the other. The cinder concrete, as is commonly believed, is much better as a heat insulator than the stone concrete, being nearly three times as effective as the denser stone concrete in retarding the flow of heat. It may be interesting to call attention to the heat insulation afforded by other materials. The best of the commercial articles commonly used for this purpose is compressed cork, which is nearly 25 times as effective as stone concrete. Steel, on the other hand, transmits heat from 75 to 100 times as fast as the densest of the stone concrete.

EXPERIENCE WITH CONCRETE IN FIRES

By G. E. Fisher,[1] Boston, Mass.

Non-Member

The fact that a building is of concrete construction seems to carry with it the idea that it is fireproof, regardless of occupancy. This word fireproof is a misnomer when applied to any kind of a building and it is gradually being displaced by the word fire-resistive, which includes not only concrete construction, but also the type now so common involving steel frame work protected with tile, concrete or brick. No building is absolutely fire-resistive, for the resistance offered to fire is one of degree only, and if the heat be sufficiently intense and prolonged, nothing can resist it.

At high temperatures the surface of concrete is easily injured and spalls badly when water is thrown on it, and both actual fires and experiments have proved that where these temperatures run from 1400 deg. to 1900 deg. fahr. the surface of the concrete may be injured to a depth of ½ in. to ¾ in., or even 1 in., but the body of the concrete is not affected. Excellent heat insulation is afforded by concrete, but to obtain the best results a sufficient thickness must be applied, depending largely upon the occupancy of the building under consideration. Experience has shown that 2 in. of concrete will protect an I-beam with good assurance of safety. Obviously a building having combustible occupancy should have a heavier protection of concrete over reinforcing members than one having noncombustible occupancy.

The best fire-resistive materials are usually considered to be first-class portland cement with quartz sand and broken trap rock. Limestone aggregate will not stand the heat so well as trap and the particles of gravel are more easily loosened by extreme heat. Cinders make a good aggregate for fire resistance, but the concrete made with them is not so strong as the rock concrete and cannot be used where high compressive values are necessary. Considered from an insurance point of view, cinder concrete is not so desirable as that made of trap rock on account of the porous quality of cinders; the insurance companies have learned that with cinder concrete they are called upon to pay losses on account

[1] Engineer, Arkwright Mutual Fire Insurance Company.

of damage from water used at times of fire, which percolates through the small interstices of the cinders, which the cement mixture cannot reach, to the floors below.

At the Baltimore fire there were only 27 buildings of fire-resistive construction in the whole burned area, these buildings ranging from 1 to 14 stories in height. Of this number that of the International Trust Company of Maryland had floors of reinforced concrete, and that of the United States Fidelity and Guarantee Company had floors and roof of reinforced concrete. In both cases the floors and roof passed through the fire very well and, except for slight cracking and settling in a few places, were practically uninjured. The conclusions reached regarding concrete by the Baltimore committee that investigated the fire were that, while concrete floor-arch construction was used in only a few buildings exposed to this conflagration, as far as tested the concrete stood in good shape.

At the San Francisco conflagration every type of construction was represented and the ruins afforded a most excellent opportunity for comparative study, although the information obtained was incomplete, as materials were not subjected to action of hose streams on account of failure of water supply. The Academy of Sciences building of concrete construction, six stories high, was completely destroyed, but a six-story annex had brick walls, reinforced concrete floors and concrete-filled cast-iron columns which proved an interesting feature after the fire. Owing to the unequal expansion of the cast iron and the concrete, the cast iron failed by bulging from the heat and cracking on cooling. In the basement where the fire was fairly hot the 1 in. thickness of concrete which covered the reinforcing bars proved insufficient; the heat expanded the bars, which pushed off the concrete layer and left the rods exposed.

A building for the Bakins Warehouse & Storage Company was in process of construction, being built largely of reinforced concrete, and at the time of the earthquake, two of the six floors were completed. The walls were of brick laid in lime mortar and the floors and columns of reinforced concrete. The walls were badly cracked by the earthquake but the reinforced concrete was not injured. Considerable furniture stored in this building was burned, but beyond a slight blistering of the under surface of the concrete floor, no damage resulted. In the Pacific States Telephone and Telegraph Company's building the heat produced

by the burning of the insulation on wire and other supplies was intense and protracted. The reinforced concrete beams of the roof were weakened by heat and had to be replaced, but the concrete in general stood the trial exceedingly well considering the very high temperature. The concrete floors and column protection were not damaged in the least.

In this fire, concrete, especially reinforced concrete, proved more satisfactory than any other material, though concrete in San Francisco was of very poor quality; a flimsy material stiffened with light metal had been passed as reinforced concrete. Cinder concrete was used extensively but was of a very inferior grade; much of it was high in sulphides which had a destructive effect on the embedded material, especially where slight cracks permitted air and moisture to come in contact with these sulphides and metal. It is further stated that most of the failures were the result of bad design, poor workmanship and poor materials. If, therefore, reinforced concrete of this quality could give such satisfactory results under the extreme conditions of the San Francisco earthquake and fire, it is evident that much greater satisfaction could have been given by first-class materials.

It is particularly noticeable in the study of conditions at San Francisco that after the earthquake the large number of buildings which failed to stand was due to the early collapse of protected steel frames. The failure of the protection to withstand the earthquake shock exposed the steel work to the fire and the fire damage to these fire-resistive buildings was estimated as high as 60 per cent.

Reports from fires in other sections of the country furnish further interesting information. At the Dayton Motor Car Works and Huyler's building in New York City, the fires were so hot as to destroy all inflammable material and yet the buildings themselves were damaged only to a very slight extent; the burned-out floors were occupied within two days after each fire. Another example is that of a two-story building of reinforced concrete construction used for drying purposes; this building was considerably exposed by frame buildings adjacent to it, and at the time the frame buildings burned, one part of the concrete structure was subjected to severe heat from a burning boiler house and grease-extracting building. The heat melted the wire glass in the windows and burned up all combustible materials in the finish of the building, but the damage to the concrete walls and

floors was very slight. Still another case is that of a reinforced concrete building, four stories in height, in which the heat from a fire was so intense that it fused a piece of cast iron into a shapeless mass, but the only damage resulting was that in several places throughout the building the concrete was split off to a depth of ¼ in. to 1 in.

In the case of an extremely hot fire in a pulp and paper mill, the principal effect of the heat observed was to expand the floor and to cause a movement of the columns. On the morning after the fire, while the concrete was still hot, the end wall of the mill was noticeably out of plumb; later on, as the wall cooled, it drew back to the perpendicular. There were several minor breaks in the concrete and some parts of it were spalled off to a depth of about 2 in. Where the concrete was rich in mortar there was less damage than where it was stony, the mortar acting as a protection to the aggregate. Where the fire was hottest the concrete was softened for an average of 1 in. so that it could easily be knocked off with an ordinary hammer.

It is one of the requirements of our Mutual fire insurance companies that sprinklers be installed in all manufacturing buildings having combustible material either in their construction or occupancy, and in all fire-resistive buildings having combustible occupancy. A great many buildings throughout the eastern and middle states are insured which are of reinforced concrete construction, but with the exception of a few office buildings or where the building has a noncombustible occupancy, they all have sprinklers. The result is that a fire starting in any part of the building is quickly controlled by the sprinklers with but little if any damage. This combination of good construction and good sprinkler protection is one which will keep fire losses at a minimum.

Some interesting information was furnished by a fire in one of these fire-resistive buildings, which did not have sprinklers. by a fire that destroyed the contents. The building, which was occupied for general office purposes and had the usual fittings and trimmings of a modern office, was three stories in height with 17-in. walls of brick and had tile and reinforced concrete floors and roof, supported by two rows of reinforced concrete posts and beams on all floors. On account of its superior construction and safe occupancy, sprinklers were thought not absolutely necessary. The intense heat generated by the burning of

the hardwood overlay on the floors and the hardwood office fittings affected the brick walls, the concrete windowsills, and the concrete belt extending around the building at the third floor level. It is thought that most of the spalling of the concrete work was due to cold water from hose streams on the hot material. The structural strength of the concrete columns appeared to be very much reduced by the fire, and to determine whether it was necessary to replace them and the beams damaged in the fire, shores were placed under a third-floor beam ½ in. clear at the top, to take the weight, should it settle when loaded. Careful measurements were taken of the distance between the underside of beam and top of floor below. A load of 16 tons of iron was placed on the third floor over the beams to be tested, and the deflection was 7/64 in. in the center of beam. This occurred at once when the load was applied, and did not increase while the test continued, namely 3 hours. For comparison, the same load was then placed over an uninjured beam elsewhere, and the same measurements taken, showing a deflection of 6/64 in. or practically the same as found in the damaged beam. No settling could be detected around any of the damaged posts when the load was applied.

In repairing this building a cement mixture was made and the beams and columns built out with it wherever spalling had taken place. It is doubtful if a person examining the building today could detect any traces of this fire. It has been equipped with automatic sprinklers, and as a further precaution against another fire the new office furniture is all metal so far as could be obtained. From the writer's own experience, however, he would not consider this last precaution necessary, for in a building well protected with sprinklers the chance of a fire getting outside the area of two or three sprinklers is remote.

DISCUSSION

A. S. Kellogg, referring to the applicability of the results of the tests to heating and ventilating work, said that thin dense concretes seemed to be about as bad surfaces for the transmission of heat as could be found, especially in the first two or three years after the construction of the building.

C. L. Norton replied that the heat transmission value of material put on in thin sheets was a matter which must be proved with the interior heating facility arrangement described in his

paper. He did not know exactly the proper treatments to apply. In places the concrete had to be used in thin sheets on account of cost, and in comparison with other thin materials, as glass, hair-felt, etc., the heat transmission was enormous. In reply to questions as to what was the heat transmission through a wall 4 in. to 6 in. thick as compared with glass, he said that he thought the loss through a concrete slab could not be equal to the loss through a glass window, which would not dispose of heat on its far side and would not receive heat on its near side. The glass might still be much thinner and prevent flow of heat through it. In testing two refrigerators, one of a dull wood and the other of a less effective insulating material coated with enamel of a bright shiny nature, through the latter the heat entered less quickly than through the former, which was noticeable in the melting of the ice.

In answer to a question regarding his experience with concrete composed partly of granite, Professor Norton said he had a number of specimens of concrete made from typical eastern Massachusetts granite obtained somewhere near Lowell. It stood the fire very well, probably because there were no larger pieces in it than would go through a 1½-in. ring. It spalled on the outside for a depth of about ¼ in., but he considered it as good as a piece of cinder concrete, and would not hesitate to use it in preference to most of the rough stone, which when heated to a high degree split and cracked.

A. L. Williston stated that Professor Norton's experiments were conducted mostly at high temperatures while the question that came up in heating and ventilating work was on temperatures below 212 deg. fahr. At the higher temperatures it was found that the conductivity increased as the temperature increased, also as compared with age, moisture, etc. He wanted to know if the presence of water would not make it a poorer conductor or poorer insulator. Professor Norton replied that he could not answer that question. A year ago he would have stated that he knew, but six months ago an anxious inventor of a porous material came to the laboratory and insisted that his material was just as good wet as dry. This statement was not altogether true, but it was found after numerous tests that it could not be predicted what the effect would be on porous material. In regard to what difference the age made, moisture hung below 212 deg. fahr. with the green specimen. A specimen heated for days

and days at 105 deg. cent. (221 deg. fahr.) was found still to lose weight and it took something like ten days or two weeks to get all the moisture out.

In reply to a question as to experience with concrete as more hygroscopic than other forms of materials, he stated that it was certainly not noticeably different from terra cotta brick.

Mr. Williston inquired if concrete would reabsorb moisture after it was allowed to stand in the ordinary room, if in seasoning it or heating it all the moisture had been driven out, which had consumed considerable time; also if it would reabsorb more than brickwork. Professor Norton answered that he did not know what brickwork would do, but concrete would reabsorb slowly for a long time, back to its constant; he had taken specimens and dried them out thoroughly and they began to pick up moisture within ½ hour and then reabsorb slowly for 20 or 30 days.

SOME OF THE PROBLEMS ENCOUNTERED IN THE DESIGN, CONSTRUCTION AND EQUIPMENT OF THE MODERN COTTON MILL

By Frank W. Reynolds, Boston, Mass.

Member of the Society

Among the problems entering into the design of the cotton mill, the most important are the selection of the proper site, the proper arrangement of the buildings to suit the site, the proper arrangement of the buildings for the best placing of the machinery and routing of material, the proper design of the buildings for strength, rigidity and natural lighting, the proper arrangement of power plant and the arrangements of power distribution, artificial lighting, heating and air conditioning in the work rooms and fire protection. Also the toilet rooms and other sanitary features must be considered. In commencing the study of a new mill plant the usual order of procedure is to organize the machinery equipment for the goods to be manufactured. For a given product either of yarn or cloth, the machinery equipment is calculated and tabulated on standard forms, which determine the numbers of machines in each process with the speeds and production of each machine. With this information as a basis the next step is to arrange the given number of machines in proper relation to each other so that the routing of stock in process of manufacture is accomplished without interference or unnecessary travel and so that future extension of the plant may be made in an acceptable manner.

Naturally, the next considerations are the proper width and height for the buildings, the spacing of columns to be adopted, the height of story, whether the spinning department and weaving department shall be in one and the same building or in separate buildings, whether or not mechanical or electrical transmission shall be used, and many other items which affect the arrangement of the projected mill.

This study of the arrangement of machinery and buildings is one of the most necessary and interesting parts of the labor of designing a plant and upon a proper solution depends in great measure the success or failure of the plant from an economical operating standpoint. Much unnecessary labor in the mill is often expended because of the poor arrangements of buildings forming parts or the whole of a group and the equally poor arrangement of the machinery within the buildings. It must be realized that the least number of motions made and the shortest distances traveled in manufacturing operations are conditions to be sought and not deliberately neglected.

At this stage also the question of the site becomes predominant. It is something always to be reckoned with and sometimes contended. Shall the buildings be arranged to suit a given site and perhaps be poorly arranged, or shall the site be purchased to suit the best arrangement of buildings? Oftentimes the buildings must be arranged to suit the site and there is no alternative. This is particularly true of sites for new mills in cities or for extensions of existing mills either in cities or in the country.

It is assumed that the mill will be built in the country on a site where extensions may be made as they are required, where water exists, where spur tracks may enter the property and where there is so much land available at a reasonable price that the manufacturing buildings may be arranged as desired and the village planned to meet the requirements of healthful living. Also an expected product of 4000 lb. in 10 hours is assumed which determines the equipment at 65,000 spindles, with preparatory machinery and 1200 looms. There must be a storehouse for cotton, a picker house, a carding and spinning mill, a weave shed, a separate cloth hall, a storehouse for cloth, a separate repair shop, a waste house and a power plant arranged for the mechanical transmission of power to both mill and weave shed.

The width of the mill is determined by the arrangement and length of the mules which are placed across the mill to obtain the best light. This gives a width of 105 ft. for this building. The length of the mill is determined by the arrangement of carding and roving machinery giving a length of about 480 ft.

The number of stories is determined by the types of machinery used. It is necessary to have mule spinning for the filling yarn and ring spinning for the warp yarn. It is essential that these rooms should be separated if the mill can be so arranged. By

placing the carding department on the second floor, the mule spinning on the third floor and the ring spinning on the first floor, practically all of the space will be used to good advantage, and the machinery will be arranged to avoid cross-travel and unnecessary handling. The mill then should be three stories in height.

The width of weave shed is determined in this arrangement rather arbitrarily by limiting it to 155 ft., but arranging for overhead light. The length will be about 550 ft. While weaving mills are built 150 ft. wide without overhead light the results are never satisfactory from any standpoint, except possibly that of first cost when compared with the results obtained from a good weaving shed with overhead light. It has been proved in one plant at least that the cost of weaving has been decreased 50 per cent and the cost of artificial lighting 66 2/3 per cent in a new shed when compared with the costs of the work in a mill 70 ft. wide having light only from the side walls. Perhaps this is an extreme case, but it brings out the point that a weave shed is better than a weaving mill.

For mill buildings there are several forms of construction: (*a*) slow-burning mill construction with wood beams; (*b*) a variation of the first form using steel beams; (*c*) reinforced concrete construction. The first two forms have been and are used for nearly all mills. In the writer's opinion they have served their purpose and may be superseded by the third, which is a better form for practically every kind of mill or storehouse construction at nearly the same cost. It has many and decided advantages over other forms of construction which have been brought forward many times. Mills so built are rigid, they have the maximum amount of light areas in side walls, the cement floors may be smoothly finished and all wood floors eliminated, the interior walls, posts and ceilings may be painted immediately after completion, giving the best interior lighting effect; the stairways will be fireproof; all motors, shafting, piping and wiring may be as easily and more securely supported than from wooden surfaces and all machinery secured to floors without trouble; above all there will not be deflection in the floors between beams making the realignment of machinery so common in wooden mills a neglected feature. Furthermore, to answer an oft-repeated question, it should be said that belt holes in floors can be as readily arranged as in wooden floors. Therefore, in constructing the

modern mill reinforced concrete construction is to be adopted, which certainly is the most modern of all forms applicable to such structures.

For the mill building 105 ft. wide, a proper height of story would be 15 ft. from the top of one floor to the top of the next floor. The transverse bays would be 25 ft. on centers and the longitudinal bays would be 10 ft. 8 in. or 11 ft. on centers. In a building three stories high, with the usual form of mill construction, the floor beams would be 14 in. by 16 in. and columns not over 12 in. in diameter in the lowest story. In the reinforced concrete construction the same spacing of beams and columns will be adhered to: this has been demonstrated to be a more economical spacing than to omit every other column and run girders lengthwise of the building over each row of columns. In the three-story building of concrete construction the first-story columns would be 16 in. sq. The beams would be 12 in. wide and 19 in. deep from the bottom of the floor slab. The floor slab would be 6 in. in thickness and the top would be finished with a granolithic surface eliminating all wooden floors. The wall columns would be 12 in. by 16 in. and all of the space between these columns would be devoted to windows. The resulting construction will be absolutely rigid and secure with the maximum amount of area for light in the side walls and would be as nearly incombustible as a building can be.

Compare this construction with the ordinary mill construction and note the differences in rigidity of construction. In the ordinary mill are a series of brick piers for the outer walls connected above and below the window openings by spandrel walls. In each brick pier at the floor line, if the floor beams are of wood, is an opening 15 in. by 18 in. by 12 in. for the reception of the end of the floor beam. This means that at each floor line each outer brick pier has nearly one-half of its area cut away for the reception of the beam. In the concrete building nothing is cut away and the junction of the floor beam and column is absolutely rigid so that the entire frame when erected is as secure and stable as a riveted steel structure. Take the case of the interior columns; in the building of mill construction the first-story column will rest upon a cast-iron base plate and upon the top of this column will be placed a cast-iron capital and on the cast-iron capital a cast-iron pintle about 22 in. in height varying from 4 in. to 6 in. in diameter. There is no rigid connection

between the capital and the bottom of the pintle or between the top of the pintle and the next column, and this series of joints will continue up through the entire height of the building. At each floor line the cast-iron capital will support wooden floor beams, and these floor beams where joined at columns, are secured to each other by dog irons or joint bolts, but these do not add materially to the rigidity of the structure. Compare this interior construction with reinforced concrete construction where the floor beams and the posts are so rigidly connected that there is no chance of moving them in any way. In other words, the reinforced concrete structure becomes practically a unit from bottom to top.

An example of a reinforced concrete mill which will bring out some of the points mentioned, is the Maverick Mill in East Boston which was completed about two years ago. The main mill is 550 ft. long, 129 ft. wide, 2 stories and a basement in height and planned for two additional stories. The weave shed is about 341 ft. by 231 ft. and is at present large enough to take the looms which will be necessary for the machinery installed in the present two stories. In the future when the two additional stories are placed on the mill the shed will be doubled in size and the ultimate plan is to make the property consist of two spinning mills, four stories high and one large weave shed 681 ft. by 461 ft.

MODERN METHODS OF LIGHTING IN COTTON MILLS

By Albert L. Pearson, Boston, Mass.

Member of the Society

This paper is intended to call attention to some of the forms of illuminants and the underlying principles to be followed in making a layout for a cotton mill. As electric light has become the standard, it is the only one which will be considered. There are two principal forms of electric lamps, arc and incandescent, and there are several types of each.

There are a great many systems of arc lighting in use in mills today and some of them are quite satisfactory. The open carbon arc used with high-voltage constant direct-current generators has been displaced in general by the enclosed carbon arc operated in multiple on low-voltage direct or alternating current circuits. The intensified carbon arc is doubtless the best of this class and due to its design the principal objections to the other types of

arcs are practically overcome, that is the traveling of the arc around the crater causing varying shadows and the change in position of the arc relative to reflectors, thus interfering with the working of any well planned scheme of illumination. Flame arcs are not generally used indoors except in foundries, machine shops with very high roofs, or similar places. As the light is very penetrating, they possess advantages in smoky or cloudy atmospheres.

The mercury arc is finding a place in machine shops and textile plants, and is meeting with great favor in the silk industry. The principal objection to this lamp is the color of the light, a cold green; but it possesses two distinct advantages, great diffusion of the light due in a large measure to the fact that it emanates from a line rather than a point and the line distinction or clearness with which threads or lines may be distinguished. I believe it has been proved that this light does not produce injurious effects upon the eye, as noted from tests made by Dr. C. H. Williams and Dr. Louis Bell upon a number of persons who have worked in the light of this lamp. A fluorescent reflector is being developed which is intended to supply the missing red rays to a certain extent and thus make the light more natural. A new form of this lamp is also being developed, namely, the quartz tube, which will compete with flame arcs for foundries and similar places.

Of the incandescent class, the tungsten lamp is the most efficient, 1.25 watts per candle power as against 3.6 watts for the carbon lamp. The tantalum lamp falls about midway between these two for efficiency, namely, 2.0 watts per candle power. In its present high state of development, the tungsten lamp is practically free from the early defects. This lamp works equally well on alternating or direct current while the tantalum lamp gives best service on direct current; alternating current produces the effect of repeated blows and the filament breaks in a short time, higher frequencies having worse effect than low. This lamp, therefore, should not be used on alternating systems.

In addition to its efficiency the quality of light from the tungsten lamp is superior to that of other illuminants of this class, most nearly approaching the ideal. This lamp is the greatest competitor of the mercury arc, or Cooper-Hewitt lamp, and is being adopted as the standard of best practice for incandescent systems.

It is only during the past few years that attention and careful

study have been given to the proper arrangement of lighting systems in mills. There are a number of fundamental principles which should always be followed out in making a layout:

a As the operative is the one for whom the light is provided, he should be given every consideration.

b Lamps hung low down which can be adjusted by the operative should be avoided wherever possible. Not only is he liable to experiment with the lamp and waste time but may thus interfere with the work of other operatives.

c Lamps should be arranged to give uniform illumination at the working plane, avoiding shadows as far as possible and particular attention should be given to the requirements of each machine.

d White walls and ceilings are advantageous and add to the effectiveness of the lighting system. With individual driving of machines it is possible, owing to omission of overhead belts and shafting, to keep the rooms cleaner than with mechanical or group driving, thus benefiting the lighting system.

e On account of glare, low exposed units should be avoided. In places where it is necessary to have the lamps low down, reflectors which will entirely conceal the filament should be used. In such cases it is usually necessary to provide lamps close to the ceiling for lighting shafting, etc.

f The position of lamps should be carefully determined, both as to spacing and mounting height. In general the height of the lamp above the floor should be such that with the spacing available the lines representing the angles of maximum illumination with a given type of reflector will cross at the working place.

Each problem must be considered by itself. A system of illumination which works out well in one case may be anything but what is best suited for another. There are a number of points in favor of good lighting, viz: safety, better sanitary conditions, and better quality of work and increase in production.

The best lighting is provided for the most particular process—weaving. The amount of light and arrangement of lamps depend upon the nature of the work and character of the machines. In places where very good light is not required or where it is

used for comparatively short periods of time, obviously it does not pay to invest so much for this part of the equipment as in places where it is required for long periods or is depended upon for quality of work. But lighting systems cannot be worked out as formerly—so many watts or candle power per square foot—but a study must be made of conditions so as to produce a layout which will prove economical and bring forth results.

The distributing systems should be carefully worked out in order to secure good voltage regulation. Circuits and switching should be arranged with respect to different processes in such a way as to eliminate the use of power for lighting in sections not in use. On low frequency alternating-current systems small incandescent lamps should be avoided as much as possible on account of flicker, which is more troublesome with the higher efficiency lamps.

AIR CONDITIONING FOR TEXTILE MILLS

By Frederick W. Parks,[1] Fitchburg, Mass.

Non-Member

Artificial humidification is no longer a theory. For years it has been on trial in cotton manufacturing, and rapid progress has been made. Knowledge of the subject is becoming more general, and the needs for textile conditions are better understood by mill men and the practice is growing more standardized. Humidifiers are no longer considered as a luxury or a whim. Few new textile mills are now built without at least considering the need of humidifiers, and few cotton mills are now built without installing humidifiers at the start.

There are so many types of apparatus on the market that the engineer or mill owner should have no trouble in selecting one best suited to the needs of the case. Some are designed especially for new mills, others either for old or new plants, some for small isolated units, and so on.

Last fall in preparing a paper on the subject of Humidifiers and Their Results for the National Association of Cotton Manufacturers, the writer sent circular letters to textile plants throughout the country, and 81 mills replied. As evidence of the value of humidification, an analysis of the reports from these mills is highly interesting. They were as follows: the influence

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of humidifiers on production, floor sweeps, invisible waste, second quality goods, static electricity, broken ends in spinning, loom shut-downs, strength of product, mill temperature, health of operatives and estimated return on investment.

It is an interesting fact that not one unfavorable reply nor discordant vote of any sort was received. The experience of one mill (a Northern cotton yarn mill built about three years ago and humidified when built) is interesting enough to quote here: "Our invisible waste for 1911 was 1¾ per cent, which is very low. Our production was 93 per cent. Our regain from cotton to yarn averaged 6 per cent on 2,000,000 lb. of cotton per year. Our humidifiers cost $10,000."

There may be an honest difference of opinion as to how this regain should be figured. Six per cent of 2,000,000 lb. of finished yarn at 24 cents per lb. is $28,800 or 6 per cent of 2,000,000 lb. of raw cotton at 10 cents per lb. is $12,000. Either way you figure it, the humidifiers were a good investment. There are hundreds of such cases.

These reports were not obtained for the purpose of exploiting any particular make of humidifiers, for these 81 mills had 11 different types of humidifiers in use. They represented silk, rami, worsted and cotton mills, although cotton mills predominated. In numbers they were equally divided between the North and the South, so the reports may be considered as fairly representative of the textile industry.

In building a new mill, admitting humidification to be necessary, the next step is the selection of the proper type of apparatus. Some sort of system can be purchased at almost any price, but sufficient capacity should be made sure of. Higher humidities are being demanded right along. The man that asked for 65 per cent in cotton weaving five years ago is now demanding 75 per cent and wishing he could get 80 per cent.

Theoretically humidification is only one of three treatments that the mill air needs. The other two treatments are ventilating and heating, and these three functions combined may properly be called air conditioning. Some light may be thrown on this subject if the demand and peak load of each of these functions is considered so as to determine their relationship to each other.

a. Heating

Demand—during cool months of spring and fall and cold months of winter.

Peak—usually between 3 and 8 a.m., and often a slightly lower peak after sunset on cold days.

b Ventilation

Demand—only for rooms thickly populated, and usually coincident with heating season.

Peak—no peak in average plant. Ventilation if required at all is in use only during working hours and load is very constant or none at all.

c Humidification

Demand—the season is longer than for heating or ventilating, greatly affected by goods made and natural surroundings.

Peak—come in cold and dry windy days of spring, fall and winter, also early mornings during heating season and especially Monday mornings when mill has dried out over Sunday.

From this brief analysis it will be seen that there is no close relationship between these three variables, for each must be capable of adjustment or operation at any load at times entirely independent of the other two, or in any possible combination with the other two. Take for instance, a zero morning in winter. The heating system may be run at peak from midnight till starting time; at 5 o'clock the metal will be warm and there will be no danger of precipitation and rusting, and thus the humidifiers may be started so as to have a proper amount of humidity when the power starts. With the starting of the power and the coming to work of the employees the ventilation is started at peak and maintained so all day. This air change may call for more humidity. By 8 o'clock the heat of the machinery and the improved circulation of air due to revolving shafting and belting have increased the temperature so that part of the heat can be shut off. By 9 o'clock more heat may be shut off if the sun is bright and there is no wind, yet the humidifiers and ventilation may not have been disturbed.

This condition may be maintained until noon, when the ventilation is shut off during the noon hour because the occupants have left. The humidifiers may or may not be shut off, depending on atmospheric conditions. At sunset more heat is needed, but the demand is not so great as in the early morning because the mill is full of warm machinery. At closing time the ventilation, humidity, and heat are stopped, and the process is repeated

the following day. Any working day in the year will call for a similar variation of these three widely varying functions.

It is obvious that the amount of ventilation is determined by the amount of odor or dust and the number of occupants. A weave shed with common looms, running four looms to the weaver would demand more ventilation than the same shed with Draper looms, running 16 looms to the weaver. It is also obvious that a thinly populated room in which an air change of once in five or six hours would comply with the Massachusetts school-house standard does not need to have its air changed every 20 minutes.

It is a fact that most textile mill heating and especially cotton mill heating comes outside of mill hours. It is somewhat startling, too, to learn that a mill located in Pennsylvania as an average of northern and southern locations, will need to run its heating system at full capacity less than 5 per cent of the total yearly heating hours. For New England the percentage is perhaps from 7 to 10 per cent. The rest of the heating hours the heating system is underloaded. It is necessary then to select a heating system which is capable of economical operation at less than full load, a point which is often overlooked. Many heating systems will operate at maximum efficiency only at peak load, with the resultant evils at light load of overheating and waste of fuel. And in cotton manufacturing especially, overheating may prove very expensive from the standpoint of product.

DISCUSSION

In the discussion which followed the presentation of these three papers, the question of suitable floors under the new conditions of concrete mill construction was touched upon extensively. Mr. Reynolds, in reply to a question regarding dusting of concrete roofs and floors, stated that he had effectually prevented dusting by the use of just enough oil in the floors to keep the surface fairly well polished. In the spinning alleys the floors kept just like glass. Of course, the trucks knocked out or chipped out pieces occasionally and these became holes, but they filled up rapidly. Some floors have been treated successfully with boiled linseed oil. As to the matter of trucking, Mr. Reynolds expressed his opinion that if the proper amount of cement were put in the concrete and if it were properly troweled down, no trouble would be experienced if trucks having wide wheels were used. As to

experience with factory operatives, he referred to a case where, in the original section of an automobile factory, wooden floors were used, but in later extensions, concrete floors were tried and proved so successful that the wooden floors were finally eliminated from the entire plant.

F. W. Dean referred to a case where steam pipes had been embedded in the concrete floors to enable them to be heated for preventing complaints from the operatives against coldness of the floors. For hard usage, however, he favored wood blocks for floors of factories and machine shops and referred to a mill he had designed in which wood block pavements had been used for floors with very satisfactory results under hard trucking service.

S. E. Thompson did not share the belief that concrete floors could be built successfully to withstand trucking. He referred to a test which he had made in order to determine what precautions were necessary to provide good wearing qualities in a concrete floor and pointed out the fact that an exceptionally good surface for the floor would not be glossy but would wear and dust; furthermore, in wearing down it would become a dead white color. One of the chief points in making a proper surface was found to be in the use of a sand of fine aggregate but which was not dust; this seemed to be a simple matter, but he stated that most of these floors were made of ordinary bank sand.

Henry Bartlett told of some experience with concrete floors in railroad shops in which difficulties were experienced, not because the floors were cold, but because they were hard. He had found that concrete floors would not stand heavy trucking and the rolling around of locomotive driving wheels. Floors constructed of spruce planks with maple flooring on top had been tried but would not stand up under these conditions, and subsequently heavy creosote wood blocks were tried with better results.

A. L. Williston referred to his experience with concrete floors in school laboratories and school shops, in which a great deal of difficulty was experienced with dust and grit from the floor surface and expressed the opinion that the life of machinery installed on concrete floors was thereby reduced. He touched upon the condition which caused this disintegration of the floor and stated that a microscopical examination of a concrete floor surface would not show a solid mass, but rather particles of the aggregate with very appreciable open areas between them; the

surfaces of the sharp sand particles did not come together, but the points of them frequently came together and occasionally overlapped. It was from this cause that trucking and hard usage tended to disintegrate the surface structure and it was suggested that if means were found of filling up these voids with some sort of an elastic cement, better results would be obtained with the floors. A few of the large paint manufacturers had been conducting rather extensive experiments to find out what materials would go into the concrete and satisfactorily fill up these voids, or at least the largest part of them, but most of the information which they have obtained was inaccessible. A trial of one compound manufactured by a Philadelphia concern was found to make a great difference in wearing qualities of the concrete floors; the compound seemed to fill up these voids and make the cushioning effect which resulted in the perfect condition of the floors. It was the speaker's experience, however, that people did not like the hard unyielding surface of the concrete floor to stand on all day. Neither the students in the laboratories nor the instructors liked them and they could not become accustomed to it. While he agreed that in a great many industrial plants, the disadvantages of the concrete floor were unquestionably offset by its advantages, he felt that the wood blocks installed on end in concrete was the best floor construction that could be used.

Mr. Parks, in reply to a question concerning humidity control, stated that the distribution of the humidifying apparatus over the average textile mill was determined largely by the percentage of humidity that was needed in the various processes of manufacture, the most common practice being to have the apparatus distributed fairly frequently over the mill. In fully 90 per cent of the textile plants, the humidifying process was applied independently of ventilation. Of course, in many of the older plants, ventilation was obtained merely by opening the windows, but in recent years more attention had been given to this matter. So far no ill effects had been observed from the use of humidification on the health of the operatives, although he suggested that if a high humidity, say above 80 per cent, were used, it might begin to be harmful. He stated that it was now viewed by the medical profession as advantageous to provide humidity regulation, and referred to some machine shops that had put in some kind of air-conditioning apparatus from the standpoint of benefit to the operatives, while others had made

use of humidity control from the standpoint of removing smoke and dust.

E. D. Lyle stated that humidifiers were used in lithographing plants and in many processes of manufacture where a fiber was used; in processes of this kind and in many plants where gases were used, humidifying was very advantageous. Candy manufacturers, film manufacturers and tobacco manufacturers were perhaps the largest users of this process, although the field had grown and was growing constantly and it could not be predicted where it would stop.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Not so very long ago a man thought that he knew everything about his engine if he had taken an indicator card. This is no longer so. Of late, it has become more necessary than ever, from an economical standpoint, to produce power as cheaply as possible, while the appearance of comparatively new sources of power, such as the gas producer and gas engine, has made an exact determination of costs and efficiencies more valuable than before, such data being used for determining the selection of the prime mover, a state of affairs which did not exist in the days when the selection was limited to the reciprocating steam engine. We witness therefore an appearance of a series of methods for a better and more practicable use of indicator diagrams, indicating devices, etc. In this country this tendency has found an expression in the beautiful work of Mr. Clayton published in *The Journal* last year.

THIS MONTH'S ARTICLES

Among this month's articles will be found an abstract of a paper by Mr. Leinweber on Diagram Characteristics which, though not of as fundamental a character as Mr. Clayton's, will be of great interest especially to internal-combustion engineers. The same tendency to break away from the somewhat loose methods and conceptions of a few years ago is manifested in Professor Bouasse's discussion of the Young modulus in which he shows that the current definition of this coefficient covers only a particular case, a general definition being also given. The article by Dumanois on the application of Diesel engines to driving battleships brings out a fact which, though not entirely novel, has not yet become fully known, viz., that at certain periods of operation, the actual pressures in Diesel engines may be three or four times as great as the normal pressures, a fact of considerable importance when it is remembered that the normal pressures are as high as 35 atmospheres. The attention of steam engineers is called to the description of tests made at the

Bollinckx Company's works in Belgium to determine the methods of prevention of the somewhat mysterious phenomenon known as water hammer. These tests have shown that a few simple precautionary measures are all that is necessary. Attention is also called to the article on welding of steam boilers and the data on some boiler explosions in Germany, interesting in showing how thoroughly each accident of this kind is investigated on the other side of the water. Reference to the description of the Mestre Squirrel Cage Superheater has already been made in *The Journal* for May. In compliance with a number of requests and inquiries, a full description of this device is given in this issue. Refrigerating engineers will be interested in the New Tables and Diagrams for Sulphurous Acid, by Dr. Hýbl. On account of their importance, the tables are fully reproduced, but it was not thought advisable to reproduce the entropy diagram, since, in its reduced form, it could not be used for practical purposes. In the section Miscellanea will be found a defense of the Taylor system of management by H. Le Chatelier, interesting both because of the prominence of the author, and the lucid manner of meeting the stock objections made to this system.

Air Machinery

New Designs of Turbo-Blowers and Turbo-Gas-Exhaustors for Metallurgical Plants (*Neuere Ausführungen von Turbogebläsen und Turbogassaugern für Hüttenwerke*, Ernst Blau. *Die Fördertechnik*, vol. 6, no. 4, p. 77, April 1913. 5 pp., 9 figs. *d*). Description of new types of turbo-blowers and turbo-exhaustors built by Brown, Boveri & Co., of Baden, Switzerland. Fig. 1A and B shows the operating characteristics of this type of blower. Fig. A has been obtained from tests of a blower without water cooling, compressing 1200 cbm/min. (say 42,000 cu. ft. per min.) to 320 mm (12.5 in.) mercury, and driven by a combined turbine running at 2900 r.p.m.: a, b, c and d are pressure-volume curves, a', b', c' and d' steam consumption curves, and η efficiency curve. The amount of air taken in has been determined in the usual manner by means of a calibrated nozzle, the various amounts and pressures being obtained by varying the position of a hand wheel on the turbine governor. Fig. 1B gives data for a blast-furnace blower designed to deliver 850 cbm/min. (30,000 cu. ft. per min.) compressed to 250 mm (9.8 in.) mercury, driven by an electric motor: a and b are pressure-volume and power-volume curves respectively, c is the limiting curve for constant load.

The article further describes the construction of a turbo-blower for supplying air at a higher pressure to converters. The following device is used to equalize axial thrust in single end blowers: behind the last runner on the shaft is wedged on a disc running between two labyrinth

packed surfaces in front of a closed chamber. When the final pressure of the compressor becomes too great, it spreads through a slot in front of the disc to a space behind it, and the shaft is displaced towards the suction side of the blower by the pressure acting on the comparatively large rear surface of the disc. At this moment the slot in the rear labyrinth packing opens a little, a communication between the back space and the atmosphere is established, and as a result the pressure on the rear surface of the disc falls off and the shaft returns to its initial position. In actual

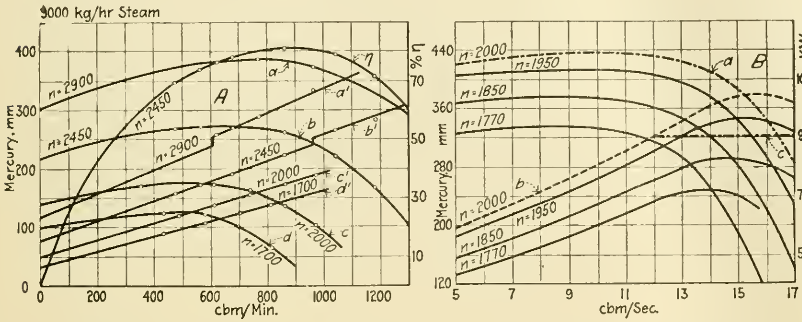

Fig. 1 Operating Characteristics of the New Brown, Boveri & Co. Turbo-Blower

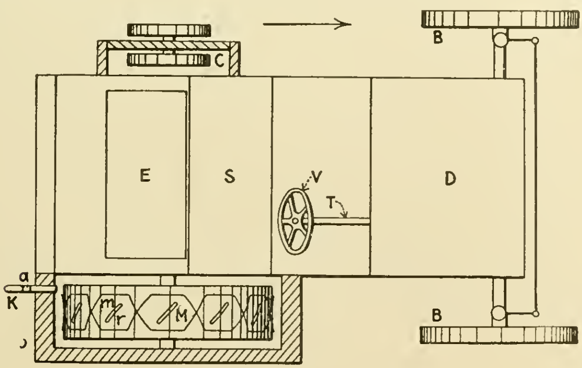

Fig. 2 Gilbert Tractor

practice the pressure equalization occurs with such rapidity that to all practical purposes the disc is always in its middle position. This arrangement is automatic, and has the advantage of making unnecessary the installation of a high-pressure stuffing box. The collar thrust bearing serves only to keep the shaft in position, but not to take up the axial thrust.

Farm Machinery

The Gilbert Tractor (*Le tracteur de M. Gilbert*, Fernand de Condé. *Bulletin de la Société d'Encouragement pour l'industrie nationale*, vol. 119, no. 3, p. 481, March 1913. 1½ pp., 1 fig. *d*). The Gilbert tractor has five wheels: the two front wheels (Fig. 2) *B* are guiding wheels; two small

wheels on the left in the rear are in one piece and on the same axle, and are acting as road wheels; the large wheel on the right is the driver. The front wheels are connected with the underframe by means of a central steering swivel which permits of a considerable displacement of the wheels in the vertical plane with respect to one another, and a great obliquity with respect to the two axles, without impairing the stability of the tractor. To increase the adherence, the rim of the driver *M* is provided with striæ *m*, and in addition, steel plates are arranged to come out through the slots *r* and penetrate into the ground; while in the upper part of the wheel they disappear completely inside the rim, in the lower they stick out about 0.12 m (4.72 in.); this is achieved by fixing these plates to levers disposed in a manner around the hub such as to have a motion eccentric to that of the wheel; this arrangement helps also to rid the wheel and the plates of earth that might otherwise stick to it. When the tractor is traveling on common roads, i.e., doing no field work, the plate device is turned through 180 deg., so that the plates stick out of the upper part of the rim, and do not interfere with the motion of the tractor. The draw-bar *K* can be moved from *a* to *b* in accordance with the resistance met with by the tractor. *D* is the engine (an explosion engine of 12 h.p.), *S* the seat, and *E* gasolene tank.

Hydraulics

Water Head of *1650* Meters (*Une chute de 1650 mètres. Journal du four électrique*, vol. 22, no. 398, 169, April 15, 1913. 1 p. *dh*). The author indicates briefly the stages in the adoption of higher and higher heads of water in hydraulic plants, and gives some data of the hydroelectric plant of the Société d'Electrochimie, of Paris, France, now under construction. This project proposes to use water power from lake Fully, in Valais, France, with a head of 1650 meters (5415 ft.) The conduit is to be 4½ km (2.8 miles) long made of steel tubing from 600 to 500 mm (23.6 to 19.6 in.) in diameter, and with walls 6 to 45 mm (0.23 to 1.77 in.) thick. In the upper part tubes will be welded by water gas; in the lower part, which is to support pressures up to 165 atmospheres, welded tubes would not be strong enough and therefore cold drawn tubes are to be used. The project calls for four Peltons wheels, each of 3000 h.p. at 500 r.p.m.

New Turbine Pendulum Governors of the de Temple Governor Construction Company of Leipzig (*Neue Turbinpendel der Regulatorenbau-Gesellschaft de Temple in Leipzig*, O. Moog. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 11, p. 161, April 20, 1913. 5 pp., 5 figs. *d*). According to the author's definition, a turbine pendulum governor is a centrifugal governor to be used in the first place for governing engines with a constant moment of torsion, such as water, steam and gas turbines, as opposed to reciprocating engines having a variable moment of torsion. To make governors economically and well, they must be produced in large quantities, which requires the use of special machinery. It did not pay turbine makers to go in for governor manufacture also, which consequently had to be taken up by special factories; the latter in their turn had to make the governors so that they should be good for as many uses as possible, and therefore to design them so that their main part should

apply to apparatus, notwithstanding the purpose for which it was to be used; the difference in the various kinds should lie only in the secondary appliances. This was the way followed by the de Temple Governor Construction Company of Leipzig whose pendulum governor is described in the article. The description of the governor is preceded by some theoretical considerations which, though not entirely new, do not appear to have been presented in an English publication in the same way.

Let E be sleeve pressure of the pendulum; δ coefficient of cyclic variation of the pendulum; δ_1 coefficient of cyclic variation of the regulation; ϵ_r coefficient of insensitiveness of the pendulum caused by governor friction; ϵ total coefficient of insensitiveness; s lift of sleeve of pendulum; s_r reduced lift of sleeve of pendulum; μ_r reduced mass of pendulum; T_a starting time of the engine; T_s closing time of the regulation; T_1 relative closing time of the regulation; T_p natural period of oscillation of the governor; T_r period of oscillation of the regulation, C_1, C_2, C_3 ... constants.

As shown by Tolle, in the case of a direct regulation of an engine the most advantageous coefficient of cyclic variation is determined by the equation:

$$\delta = \delta_1 = C\sqrt[3]{\frac{s_r}{T_a^2}} \qquad [1]$$

and in this case the coefficient of insensibility has to be made $\epsilon \gtreqless C_1 \delta\, x$, where x is the relative load variation. A small coefficient of insensibility would lead to the pendulum oscillating all the time, while a perfectly sensitive pendulum could not be used at all. δ can decrease with the decrease of s_r, or with the increase of T_a, but in machinery without periodic variation of the moment of torsion, the starting time is made, from economic considerations, as short as possible, and the decrease of the coefficient of cyclic variations can be effected only by reducing s_r. In the case of pilot valve governing the closing time T_s and the coefficient of cyclic variation of the regulation must also be considered. The condition of stability, requiring that after a load variation the engine should pass into its new state of equilibrium without oscillations, is as follows: the natural period of oscillation of the pendulum T_p should be small as compared with the period of oscillation of the regulation T_p and T_r, which are respectively

$$T_p = 2\pi\sqrt{\frac{\mu_r\, s}{2E\delta}} \qquad [2]$$

$$T_r = 2\pi\sqrt{\frac{2C\,\delta\, T_1}{75\, Ns}} \qquad [3]$$

These equations are further transformed by the introduction of the following values for s_r, T_a and T_s:

$$s_r = \frac{g\mu_r s}{E}; \quad T_a = \frac{2C}{75N}; \quad T_s = \frac{T_1}{s} \qquad [4]$$

the last on the assumption that the governor velocity is proportional to the displacement of the pendulum sleeve out of its median position. Equations [2] and [3] then take the form:

$$T_{\rm p}=2\pi\sqrt{\frac{s_{\rm r}}{2g\delta}} \quad \text{[2a]}$$

$$T_{\rm r}=2\pi\sqrt{T_{\rm a}T_{\rm s}\delta} \quad \text{[3a]}$$

the equation of irregularity of the governor (Stabilitätsbedingung) taking the form:

$$\frac{T_{\rm p}}{T_{\rm r}}=\sqrt{C_2}\sqrt{\frac{s_{\rm r}}{T_{\rm a}T_{\rm s}\delta^2}}<<1 \quad \text{[5]}$$

The usual expression for the maximum speed deviation, in revolutions, in the case of pilot valve governing, is:

$$z=\frac{\triangle\omega}{\omega_{\rm m}}=C_3\sqrt{\frac{75N}{C}\frac{\delta T_1}{s}x} \quad \text{[6}$$

where x is the relative load variation. With the values given in [4], this becomes

$$z=C_3\sqrt{C_4}\sqrt{\frac{\delta T_{\rm s}}{T_{\rm a}}x} \quad \text{[6a]}$$

From a consideration of equations [5] and [6a] it appears that the value of δ in most cases is fixed, and must not exceed a certain definite limit. While it would appear from [5] that $T_{\rm s}$ be selected as large as possible, equation [6a] is against that by showing that with respect to the maximum permissible speed deviation it is advisable to make $T_{\rm s}$ as short as possible. It is not economic to make $T_{\rm a}$ larger than otherwise necessary, and therefore the best way to limit the irregularity of the governor appears to be still to make the reduced lift of sleeve of pendulum small. Insensitiveness of the pendulum is particularly harmful in the case of pilot valve governing, since it not only increases the maximum speed deviation, but also the irregularity of the governor. On the other hand, a perfectly sensitive pendulum is also inapplicable owing to the impossibility to make a pendulum having no mass. The rise of periodical oscillations is prevented by the action of forces in the pendulum itself, but insensibility of the pendulum, while in its equilibrium position, is harmful in that it prevents the pendulum from exercising at once its regulating influence: insensitiveness of the pendulum should therefore come into play only after the beginning of the governing action. The de Temple governor itself will be described in an early issue of *The Journal.*

Internal Combustion Engines

Variable Stroke Engine (*Le moteur à course variable*, G. Lienhard. *La Technique automobile et aérienne*, vol. 8, no. 88, p. 52, April 15, 1913. 3 pp., 5 figs. *dt*). Principles of operation of the new valveless variable stroke internal-combustion engine, Itala, in which the usual system of change speed gears and transmission by crank and connecting rod are replaced by the novel arrangement shown in Fig. 3A (the connecting rods shown by their axes only). The piston A is free to move in a cylinder (not shown); the connecting rod B articulates in a with the piston, and in b with another connecting rod B_1 in its turn having a further connection in c with the crank M of wheel R, in mesh with an endless screw in

a way such that it may either move and turn the crank with it, or be kept in any desired fixed position. In b also is articulated a third connecting rod B_2 engaging at its other extremity the crankshaft of the engine. If the wheel R is held stationary while the engine runs, the piston will have a reciprocating motion at constant amplitude. But if the wheel R be given a rotary motion, with c describing a circle about o as a center, while the engine runs, the amplitude of reciprocating oscillations of the piston will vary. The author analyzes in detail the variation of the stroke, and to do this solves an interesting problem: being given two cranks of any length connected by a connecting rod of any length, to determine the movement of one of the cranks from that of another. This part of the article is not suitable for abstracting. No data as to actual tests of the Itala engine are given.

Diagram Characteristics (*Diagramm-Characteristiken*, B. Leinweber. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 14, p. 534, April 5, 1913. 9 pp., 27 figs. *ctA*). The usual method of investigating thermo-

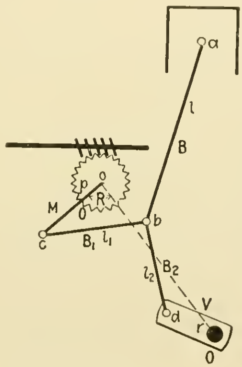

Fig. 3 Variable Stroke Itala Engine

dynamically indicator diagrams is to draw an isothermal or adiabatic curve through the origin of the compression or expansion line, or to compare the expansion (compression) line with a polytropic curve plotted to a polytropic coefficient n *approximately* corresponding to that of the actual expansion line. The angle φ is selected as above, and from it is determined, by the formula $1 + \mathrm{tg}\ \psi = (1 + \mathrm{tg}\ \varphi)^n$, the angle ψ which is then used to draw the ideal polytropic curve ($=n$) in the usual manner. This process is however little suited for the actual determination of thermodynamic processes since actually the diagram lines do not follow the ideal coefficient n, but their polytropic coefficient varies continuously. To draw ideal polytropic curves through every point of the diagram is not practical, and the author suggests a different method for plotting the characteristic curves: Divide the abscissa to a given line of change of state (Fig. 4) in a manner such that $\frac{v_1}{v_2} = \frac{v_2}{v_3} = \frac{v_3}{v_4}$; draw through the points of division perpendiculars to the abscissa, and draw, until their intersec-

tion with these perpendiculars, lines, at 45 deg. to the preceding line, from the point of division next to it: a straight line of proportionality is then obtained enclosing an angle ϕ, the dimensions of which depend on the ratio $\frac{v_1}{v_2}$. If now parallel lines be drawn from the corresponding points of the expansion line to the abscissa, and from their points of intersection with the zero-ordinate straight lines be drawn at 45 deg. to the ordinate, points of intersection are obtained which, when connected with the origin of the coördinates, give a line which, together with the ordinate, encloses an angle ψ satisfying, for the corresponding point of the expansion line, the equation $1 + \operatorname{tg} \psi = (1 + \operatorname{tg} \varphi)^n$. In the case of the ideal polytropic curve of change of state, all these points of intersection lie in a straight line, the angle ψ being constant when n is constant. In actual diagrams the coefficient n is not constant, the angle ψ varies, and the line connecting the points of intersection is not straight line, but an irregular curve.

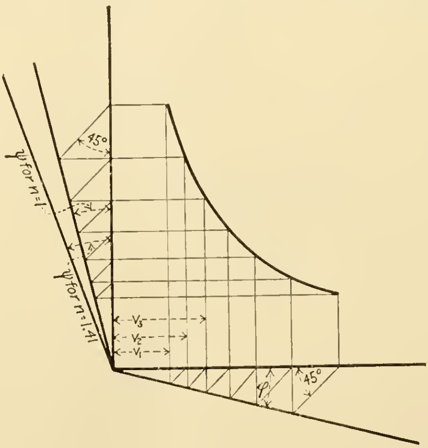

Fig. 4 Indicator Diagram Characteristics

By drawing from the origin of the coördinates two straight lines, one with angle ψ for $n = 1$ (isothermal) and the other for $n = 1.41$ (adiabatic curve), one can observe the variations of the coefficients n for different angles ψ as compared with these curves, and how the diagram oscillates between these two changes of state. The main part of the article devoted to the application of this method to the investigation of internal-combustion engines is of interest in showing how much information as to the working of such engines can be obtained from indicator diagrams with a proper method of interpreting them, but cannot be abstracted here owing to lack of space.

Application of Diesel Engines to War Vessels (*Application des moteurs Diesel aux navires de guerre*, P. Dumanois. *La Technique moderne*, vol. 6, no. 8, p. 289, April 15, 1913. 6 pp., 4 figs. *c*). The author believes that Diesel engines are not suitable for driving *war vessels*. Let P, p_m and

N be the maximum pressure, average ordinate and number of revolutions per minute of a steam engine, and P', p'_m and N' the same quantities respectively for a four-stroke cycle Diesel engine of equal power and strength. It may be admitted that the weight of an engine per horsepower is a function of these quantities:

$$W = A \frac{P}{p_m N}$$

and in the case of a Diesel engine

$$W' = 4\,A \frac{P'}{p'_m N'}$$

Hence

$$W' = 4\,W \frac{P'}{P} \frac{p_m}{p'_m} \frac{N}{N'}$$

but, since P, P', p_m *and* p'_m are constant for given apparatus, there is an advantage in increasing N' in order to reduce W'. But in the steam engine of say 6000 h.p., N is about 400 r.p.m., which is also about the maximum for N' (speed of a Diesel engine), so that $N = N'$. Since further (in atmospheres) $P = 17.5$; $P' = 35$; $p_m = 4$; and $p'_m = 7$; $W' = 57$ kg. (125 lb.) for a four-stroke cycle engine and approximately 40 kg. (88 lb.) for a two-stroke cycle engine, which is considerably in excess of the corresponding weights in the case of a steam engine (the author shows that taking into consideration the weight of the fuel, etc., the weight of a Diesel engine per horsepower must not exceed 31 kg. or 68 lb., in order to be equal in efficiency per lb. of weight to the steam engine). But the author shows further that the maximum gage pressure of 35 atmospheres in the Diesel engine when normally operating does not at all indicate the actual maximum pressure which under certain conditions may be three times as high; this will cause mechanical fatigue of the materials used and impair the reliability of the engine. Therefore, even with an engine exceeding in relative weight the steam the coefficient of reliability would be lower for the Diesel engine, and to make them as reliable as steam engines, they would have to be designed for maximum pressures up to 115 atmospheres for four-stroke cycle engines, and 80 atmospheres for two-stroke cycle engines, which would make their weight absolutely prohibitive for use on battleships. To this must be added the difficulty of construction of large bore Diesel engines, which increases more rapidly than the size of the engine. Attention of internal-combustion engineers is called to the author's discussion of the processes producing pressures three or four times larger than the normal maximum pressure: abstract cannot be given on account of lack of space.

THE MODERN GAS ENGINES AND THEIR ECONOMIC POSITION (*Die neueren Gasmaschinen und ihre wirtschaftliche Stellung*, H. Neumann. *Journal für Gasbeleuchtung*, vol. 56, no. 15, p. 341, April 12, 1913. 5 pp., 12 figs. *cd*). From a paper read at the 44th annual convention of the Silesian Gas and Water Engineers Association. The author believes that the progress of the small electric motor in the industry is due to a large extent to the greater flexibility of the electric tariffs as compared with the rigid gas rates, as well as to the fact that hitherto the first cost of gas engines

was somewhat higher, and the attendance less simple than with an electric motor. Lately however new types of extremely simple and practically fool-proof gas engines have been placed on the market, some of which the author describes: In the Deutz *naphthaline engine* the naphthaline is vaporized by boiling cooling water, the feed pipe conducting naphthaline vapor from the vaporizer to the atomizer being surrounded by steam, in order to prevent condensation of the vapor. Until the cooling water is heated up to the boiling point, which takes about ¾ hours, the enginè is driven by gas or benzole. From data given in the article it appears that in Germany the naphthaline engine, in sizes of say 6 h.p., becomes more economical than the gas engine when operated at the rate of 1750 and more hours per year, the economy in favor of the naphthaline engine increasing as the number of working hours per year grows.

Mechanics

Combined Oil and Graphite Lubrication (*Kombinierte Oel- und Graphitschmierung*, H. Putz. *Dinglers polytechnisches Journal*, vol, 328, no. 17, p. 257, April 26, 1913. 3 pp. *pt*). Exposition of the Ubbelohde theory of lubrication, mainly in connection with the problem of graphite and graphite-oil lubrication. For a detailed statement of the Ubbelohde theory see *The Journal*, June 1912, p. 963, and August 1912, p. 1245.

Concerning M. Brenier's Article on the Study of Springs (*A propos de l' étude sur les ressorts de M. Brenier*, Maréchal. *Bulletin de la Société de l'Industrie minérale*, April 1913. p. 471, 5 pp., *p*). The author, chief equipment engineer of the Paris-Lyon-Méditerranée Railroad, France, calls attention to the fact that his company has been using for 20 years a formula for the design of laminated springs analogous to that established analytically by Brenier, which proves the correctness of Brenier's method (for an abstract of the article of Brenier see *The Journal*, August 1912, p. 1250).

Definition of Young Moduli for Very Deformable Bodies (*Définition des modules pour les corps très déformables*, H. Bouasse. *La Technique moderne*, vol. 6, no. 9, p. 325, May 1, 1913. 3½ pp., 6 figs. *etA*). The author criticises the usual *definition of coefficient of elasticity* as the load which would be necessary to elongate a piece of 1 sq. in. section to double its original length, provided the proportionality of elongation to tension which holds for small tensions, would continue indefinitely. The author calls attention to the fact that this definition is usually applied to all solids indiscriminately. This classical definition means that if Fig. 5A (tension test curve, abscissae elongations, ordinate stresses) the Young modulus is measured by the angular coefficient of the curve at the origine *O*, inclination of the tangent at the start, for small loads. But there is nothing to prevent anyone from considering the point *A* instead of *O*, and since the inclination of the tangent is different there, from obtaining an infinite number of continuously varying moduli. To the objection that this cannot be done because at *A* there is a *permanent set*, the author replies: how do you know this except through assuming that each curvature of the curve of tension corresponds to a permanent set? He proceeds to

prove that this is not so. He maintains that a really elastic deformation corresponds to a reversible operation. If the curve OAB (Fig. 5A) corresponded to really elastic phenomena, it would not matter in which sense it was taken since, whether for decreasing or increasing loads, the same points would correspond to the same stresses. Generally, however, the curves for increasing and decreasing loads look more like Fig. 5B (for rubber). Since further, the Young modulus, by hypothesis, is supposed to represent a characteristic parameter of actual elastic phenomena which, also by hypothesis, are characterized by the superposition of their curves for increasing and decreasing loads, the inclination of the tangent at some point, say at B, cannot be considered as characteristic for the modulus, since the tangents for increasing and decreasing loads are entirely different, and, as seen from Fig B, may be twice as large for decreasing loads as for increasing.

The author proposes to proceed in a manner different from the usual

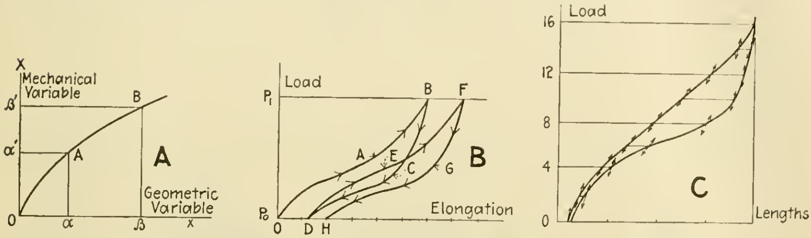

Fig. 5 Tensile Stress-Elongation and Residual Elongation Curves

one. Starting from some point A on the curve corresponding to a load P, he produces slight variations of load from $\triangle P - \triangle P$ to $\triangle P + \triangle P$. He describes successively small curves for increasing and decreasing loads *quasi rectilinear and with inclinations tending towards the same limit.* If this operation be repeated a great number of times, two little straight lines will be described exactly superimposing, and be such that their middle point corresponds to the load P and length L, and the inclination represents the Young modulus for the point in the plane having for its coördinates P,L. With a certain thread (rubber) of a definite length and the same person performing the tests it is not possible to obtain all the points on the plane (P,L), but a considerable area of that plane. The moduli at all these points may therefore be defined as follows: the inclination of small stretches of the curves, formed practically by two superimposed lines have to be determined, and from this is derived the Young modulus (taking into consideration the personal coefficient of the experimenter, and the area). This definition includes the classical definition as a particular case, but has the advantage of indicating when it may be legitimately used. It shows that to obtain the characteristic inclination from which the modulus might be derived, the condition of operating at small loads is not sufficient and in addition the effect of repeating a small cycle at light loads has to be eliminated. Fig. 5C is interesting in that it shows to what extent the inclination of small *fixed* cycles can differ from that of a large curve passing through their middle points. The im-

portance of this new difference is more evident when applied to materials such as rubber, than in connection with metals. One of the characteristics of such heterogenous materials, however, is that they *age*, which means that under certain conditions their tensile strength rapidly falls with time. One of the conditions which, in the case of rubber, appears to produce ageing with particular rapidity is rest; it is therefore of advantage to have some methods for determining the progress of ageing without accelerating it, and experience shows that one of the characteristics of the ageing process is the hardening of the material, the increase of its Young modulus; rubber with a small modulus of elasticity (perfectly pliable) becomes petrified at the end of say six months (very large coefficient of elasticity). The author describes a method of determining the coefficient of elasticity of the material by subjecting it to a series of small stresses which neither act destructively nor accelerate the process of ageing. The importance of his process, as the author claims, lies in the fact that it is scientific, and that it gives results which mean something definite. The apparatus used is very simple, and would probably be of interest to manufacturers of tires and balloon materials.

Pumps

Packing and Stuffing Boxes in Centrifugal Pumps (*Dichtungen und Stopfbüchsen bei Kreiselpumpen*, A. Schacht. *Die Fördertechnik*, vol. 6,

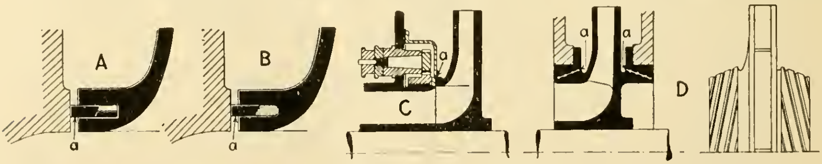

Fig. 6 Stuffing Boxes in Centrifugal Pumps

no. 4, p. 82, April 1913. 2 pp., 13 figs. *d*). A compilative description of various types of packing and stuffing boxes in centrifugal water pumps to avoid clearance losses. Several of the devices described are of American origin, and therefore omitted here. Fig. 6A represents a device patented in Germany (No. 142,214, Klasse 59 b). A packing ring *a* loosely set in the blade wheel is pressed against the casing wall by a sectional inner ring, the sections, under the action of centrifugal force, producing a good contact and thus eliminating clearance losses. In another type of the same design (Fig. 6B) packing material is used instead of the sectional ring, the action likewise depending on centrifugal force. In the German patent No. 117,218 (Fig. 6C) the packing ring *a* is adjustable, and so arranged that it may be adjusted from outside. This packing ring is provided with screw threads, to prevent its pressing too hard against the blade wheel: when the pressure becomes too great, the blade wheel itself screws it back into the casing. Apart from the fact that this stuffing does not apply to multistage pumps, it would have been very good, if it were not so costly. In the Austrian patent No. 35,965 (Fig. 6D) the packing is produced partly by the use of helical grooves, but mainly by the action of centrifugal force, and to increase the action of the latter the depth of

the grooves is made progressively increasing. This device ought to be very effective in view of the fact that the centrifugal force increases as the square of the diameter of the increasing grooves, and therefore there ought to be at *a* a pressure sufficient to make a good packing joint. The article does not state if any of these types are in actual use.

Steam Engineering

Steam Drying (*Das Trocknen des Kesseldampfes*, C. Guillery. *Organ für die Fortschritte des Eisenbahnwesens in technischer Beziehung*, new series, vol. 50, no. 8, p. 140, April 15, 1913. 1 p., 1 fig. *dp*). Since the introduction of superheated steam, steam drying has been somewhat neglected, but is really more important than ever, because the heating area has grown more rapidly than the surface of evaporation, the amount of evaporation per unit of heating area has, in locomotive practice, increased with the increased speed ot runs, while the path of the steam bubble from the fire tubes and walls of the fire box inside of the boiler has become longer. In addition, the water surface in a locomotive boiler, owing to stronger vibrations due to the greater speed of the locomotive, has become less steady than before, while the steam domes have become lower as the boiler diameter increased. All these factors are conducive to higher water content in steam, and the drying of the steam ought not to be entirely left to the care of the superheater: the locomotive will work of course, but the efficiency of the superheater will be lower. The article contains also a brief description of the *Born separator* (centrifugal type) with which tests were made on a private suburban line and have shown an economy of 7.5 per cent in the amount of water used. No exact data as to the methods of testing are given.

Water Hammer in Steam Engines (*Les coups d'eau dans les machines à vapeur*, F. Gyseling. *Revue Industrielle*, vol. 44, no. 2081/16, p. 209, April 19, 1913. 3 pp., 14 figs. *eA*). Data of experiments made at the plant of the H. Bollinckx Machine Company, Brussels, Belgium (the author is technical director of the company). For the tests a single cylinder engine was used, having diameter of cylinder 350 mm (13.7 in.), stroke 700 mm (27.5 in.), speed 158 r.p.m., admission steam pressure 7.5 atmospheres, normal power 140 i.h.p. The valve gear is by horizontal piston valves with trip gear for admission and positive gear for exhaust, the admission catch acted on by a centrifugal governor which permits varying the degree of admission from 0 to 55 per cent; exhaust lead 10 per cent, and compression lead 25 per cent; clearance only 3 per cent of the useful volume of the cylinder. The engine was built to use saturated steam. To determine more precisely the influence of water carried into the cylinder by the admission of steam, the condenser was disconnected, and the engine run with free exhaust into the air. To allow the water flowing from the cylinder to move more freely, the discharge piping having a diameter of 170 mm (6.6 in.) was set with a slant towards the outside; the exhaust steam was allowed to escape through the end of the piping, at the floor level. To make the damage due to the action of water hammer as slight as possible, special precautions have been taken. By putting out of action the front catch, the engine was made single acting, so that a water ham-

mer could be produced only in the back of the cylinder. In that case it would break off the cylinder cover which, for this particular reason, was fastened by only three bolts, and after being blown off, would strike pieces specially placed for that purpose some 5 cm (say 2 in.) away. During the tests the flywheel was connected by a belt with a pulley set on the main power shaft of the shop driven by a large motor. Owing to this arrangement the engine could not run away even while running at no-load with a large admission, because the shop shaft was driven by a motor far more powerful than the engine under test; on the other hand, with the belt thrown off from the flywheel and a large admission, very accelerated velocities could be realized. The piping is shown in Fig. 7.

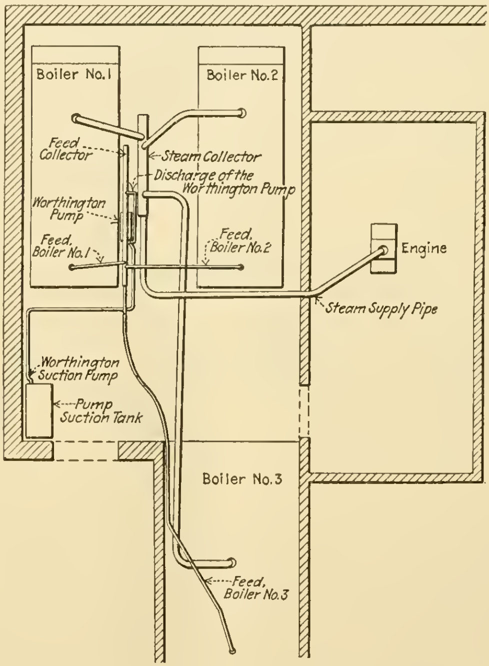

Fig. 7 Piping in the Bollinckx Tests for Water Hammer

Three series of tests were carried out. In the first series the piping was as shown, but on the delivery piping a Westinghouse double-acting feed pipe was branched on. Several trials at various degrees of admission were made, but no water hammer action observed. In the second series of tests a pocket was made in the steam supply piping, having a volume of approximately 50 liters (13 gallons) and connected with boiler No. 3 (Fig. 7) by a special pipe. At the time when this was done the engine ran on steam supplied from the two other boilers, but arrangements for changing the connections were made beforehand. After the engine reached its normal speed, the steam gate valve to boiler No. 3 was suddenly opened so as to allow the water to fill completely the pocket in

the steam supply piping. Unlike what happened previously, the water, after passing through the cylinder, came out from the discharge pipe not in a continuous stream, but in successive jets. In a later test the steam gate valve was opened as rapidly as possible, so as to fill with water not only the entire steam supply piping, but also the cylinder lagging. The water passed through the cylinder and came out from the discharge pipe in spouts. The first mass of water was thrown at a distance of about 20 meters (65 ft.), and at the same time the discharge piping received a shock which produced a rupture of one of the joints and made a gap between the pipes of about 25 cm (say 10 in.). A few instants later another mass of water was discharged through the rupture in the piping. The engine was then stopped, the discharge piping put in order, and the same experiment repeated, the water always coming out from the discharge piping in successive jets. In none of these tests did any injury to the cylinder or joints occur, and it was observed that the size of the jets of water increased with the degree of admission. In the third series of tests it was desired to determine what would happen in the case of cylinder without lagging, to draw the conclusions for superheated steam engines. To do that, the piping was changed in a manner such that the steam supply pipe opened up direct into the admission steam valve chest, and all sorts of tests made. It was found that all the water which entered the cylinder of a steam engine during admission, ran out through the discharge piping during exhaust, without causing any trouble, whatever the amount of the water or load on the engine might be. This applies only to the case when the exhaust valves are placed at the bottom of the cylinder. The fact that the water runs out entirely is due to the fact that the admission rarely occupies more than 50 per cent of the stroke, while the exhaust nearly the entire stroke, and that the exhaust valves have usually a larger cross section than the admission valves. The difference of pressure between the interior of the cylinder and the boiler does not affect the above stated observation, since at the moment of the opening of the admission valve it was insignificant. The following general conclusions as to the origin of the water hammer phenomenon have been arrived at: (*a*) in single-cylinder engines a water hammer can occur only when the discharge piping has not been thoroughly blown through; the water then returns into the cylinder, especially when the engine runs at no-load, the pressure at the end of expansion being then below that of the discharge piping. To avoid water hammer, place at the bottom of the exhaust discharging into free air, a pocket of large capacity in which the water may accumulate, and make the same arrangement, by syphon or otherwise, that the water may run out of the pocket. That is what the Bollinckx Company has been doing for 25 years. (*b*) Single cylinder condensing engines: when the condenser is in tandem, the water can accumulate in the pipe between the condenser and the cylinder which acts as a pocket; if no precautions are taken, it can then be sucked up or driven into the cylinder and produce a hammer shock, such an accident happening at starting or at sudden throwing off of a large part of the load. The Bollinckx Company uses a steam loop continuously to blow out the pocket in this kind of installations. Usually, however, water hammer in this type of machinery is due to defective working of the air pump, but may

also be due to mistakes on the part of the engineer who, e.g., while slowing up the engine previous to stopping it, forgets to close the water injection cock to the condenser: in that case the output of the pump decreases because of the decrease in the speed of the engine while the water delivered to the condenser is still the same as before, and as a result, the water rises into the cylinder which, receiving no steam, acts as a pump. Precautions: to take care of purging the exhaust piping at its lowest point; provide a float vacuum-breaker actuated on by water tending to return to the cylinder in a manner such that this apparatus should destroy automatically the vacuum in the exhaust piping; when possible, provide an apparatus regulated by the governor and automatically decreasing the vacuum. It is a very useful thing in all cases to have a steam drier installed in the piping, in which case the additional advantages will be secured of lower steam consumption and elimination of washing of cylinder walls by the water in the steam and carrying away the lubricants. A number of diagrams is given in the original article.

Welding of Steam Boilers (*Die Schweissung von Dampfkesseln*, H. Jaeger. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 14 and 15, pp. 161 and 179. 4 pp., 5 figs. *gp*). In 1912 in Prussia occurred three serious explosions of water tube boilers with headers which have attracted attention to the question as to the safety of this type of boilers generally and welded seams in boilers in particular. In the first case, in the central station of the Phoenix Company in Lierenfeld, exploded a boiler built by the Borsig Company in 1910, 412 qm. (4408 sq. ft.) heating surface and 15 atmospheres working pressure; the immediate cause of the accident being rupture of the flanged plate in the lower part of the header, 6.08 m (19.9 ft.) wide and 254 mm (10 in.) deep. The second explosion occurred in the rolling mill of the Menden and Schwerte Steel Works, with a new (built in 1911) Piedboeuf boiler having a header 3,575 m (11.7 ft.) wide by 300 mm (11.8 in.) deep, the immediate cause of the explosion being the loosening of the welded seam of the header plate which sprung open up to the corners. In the third explosion at the rolling mill Deutscher Kaiser in Dinslaken, a wall of the rear header became loose at the welded seam and rolled up to the second row of staybolts. The boiler was built in 1897 for a working pressure of 12 atmospheres, and was heated by exhaust gases. In all three cases the explosions were quite violent, the boilers being thrown at 165, 190 and 20 ft. respectively, and investigation showed that there were other causes besides possible weakness of the welded seam which in themselves might have been sufficient to account for the explosion. Thus in the Borsig boiler explosion it was found that the lower welded seam of the header was exposed to the direct action of the heating gases owing to insufficient protection by the boiler setting which had been defective for some time. In addition, boiler scale was washed out from the tubes into the front header where it caused imperfect cooling of the lower welded seam. Similar conditions have been found in the Menden-Schwerte explosion, while in the Dinslaken accident it was found that the lower row of staybolts was unusually far from the welded seam (224 mm or 8.9 in.), and in that row six staybolts were broken and several more cracks. Nevertheless, both the Prussian government and the manufacturers have organized a series of tests to determine

the strength of welded seams generally, as well as to answer the particular question as to the design of this type of boiler arising from the data given by these accidents. The Piedboeuf Company has made a series of tests with butt welded seams, and found that rupture occurred only at stresses many times exceeding those to which the seam would be subjected in boiler operation. The fracture showed a brilliant metal surface colored here and there by oxidized iron slags, the same as the surface of fracture of the exploded boiler. Since all possible care was exercised in the preparation of the tests seams and the welded pieces were sufficiently warm, it appears that with the present methods of work enclosure of oxidized slags cannot be prevented; and with thick sheets such as are used in water tube boilers, the specific pressure of the two welded surfaces against each other cannot be made large enough by hammering to force out from the joint the slags formed by the oxidizing welding flame. The following questions have also been investigated: (1) *the advisability of limiting the width and depth of headers, the former when there are two upper drums.* The use of two aggregates side by side would be about as economical in operation as one with two upper drums, while the handling of excessively large headers would be avoided; on the other hand, with the present hoisting apparatus, the latter does not present any serious

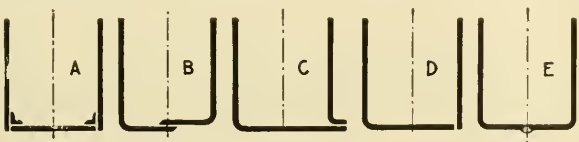

FIG. 8 VARIOUS METHODS OF BOILER SEAM WELDING

difficulties, while two units would be more expensive than one, and the total length of welded joints would be longer in the first case than in the second; there is therefore no reason for recommending a limitation of the width of headers. (2) The advisability of looking for a header design avoiding the use of butt welding entirely, or at least eliminating the lower welded seams of the headers lying towards the fire side. The following types were considered: (*a*) return to the riveting of the headers, either by connecting the side plate with the straight walls by means of angle irons (Fig. 8A), or (Fig. 8B), as in the Willmann boiler, by riveting together the front and rear walls, provided for this purpose with broad flanges, so that the rivet joint lies in the middle of the flanges serving as side plate; (*b*) by flanging both walls and making an external riveted seam (Fig. C); (*c*) by flanging the fire wall and butt welding to it the outer wall (Fig. D); (*d*) by flanging both walls and autogenously welding them in the middle as shown in Fig. E. The design shown in Fig. 8A is not advisable because it does not ensure complete safety of operation, and the row of rivets on the fire side forms a weak place in the boiler. The same applies to the design of Fig. B. A seam such as shown in Fig. C would be very expensive to make on account of the tall flanges of the inner walls, and in addition is not absolutely safe as to tightness, on account of there being only a single caulking edge. Some factories now contemplate the adoption of the design shown in Fig. D, which has the

advantage of not having the dangerous inner welding seam. (3) All experts agreed that the staybolts should be placed as near as possible to the welded joint, and not further than 75 mm (3 in.) from the wall. As to the advisability of reinforcing the staybolts and drilling their ends, opinions differ, but it appears advisable to do so, since in the Dinslaken boiler explosion it was found that six staybolts of the lower row had broken before the explosion, while several more started to crack. (4) The proposal to test the headers at a pressure double that of the operating did not meet with favor: considerably higher stresses are required to rupture the welded seam so that such a test would not really show much and it is difficult to make (difficult to make the header watertight), and the high pressure may start cracks in the header. The advisability of hammering up the seam with heavy hammers during the pressure tests was universally recognized as well as the possibility of injuring the seam by the use of too heavy hammers (sledges). Tests will be made to determine this point. (5) The author considers the annealing of the headers after the execution of welding work; even though the boring of holes and opening in the header relieves the metal to a certain extent from the stresses created by the welding process, this is not complete, and a certain amount of stresses remains; when annealed, some of the weaker places open up, while others can be recognized by the coloration of the metal sheet when cooled.

Mestre System Squirrel Cage Superheater for Tubular Boilers (*Le surchauffeur en cage d'écureuil système Mestre, pour chaudières tubulaires*, P. Lachasse. *Revue industrielle*, vol. 44, no. 9, p. 113, March 1, 1913. 3 pp., 18 figs. *d*). Description of the Mestre squirrel cage superheater for tubular boilers (for preliminary notice see *The Journal*, May 1913, p. 848). This superheater (Fig. 9A) consists essentially of: (*a*) header *B* placed transversely to the smoke box, and divided longitudinally into two chambers, *B′* and *B‴*; (*b*) six or seven vertical connectors *C* likewise divided into two compartments each, to communicate with the two chambers of the headers respectively; (*c*) superheating elements *D* located in large flue-tubes, in vertical rows, on the connectors. Wet steam from the boilers passes through pipe *A* to the first chamber *B′* of the header *B*, and is distributed from there to the front compartments *C′* of the connectors *C*, and thence to the superheating elements *D*, which convey the superheated steam to the rear compartments *C″* of the connectors, the second chamber *B‴* of the header and thence to the engine cylinders by the pipe *E*. The construction of the superheating elements is of particular interest. Each consists of a large central tube and eight or nine small tubes peripherally disposed around it in a definite manner, as described below. These outside pipes are bent in the rear part and joined to the large central tube by autogenous welding, the central pipe in its turn having a tip with a reduced diameter welded at the smoke stack end. The ends of the outside pipes are welded to the central pipe in three or four different planes in groups of two or three pipes and according to their number, each group consisting of two opposite welds or three at 120 deg. to each other. To permit the small tubes to follow the variations in length due to the inequality of their expansion as compared with that of the central tube, they are made either wave shaped (Fig. 9C) or helical (Fig. E).

The outside pipes are kept at a constant distance from the central tube by means of three groups of three to four stays, each stay connecting with the central pipe either two opposite outside pipes, or three outside pipes at 120 deg. to one another. The steam passes through the central tube going one way and returns through the outside tubes.

The advantages of the squirrel cage superheater are said to lie in the

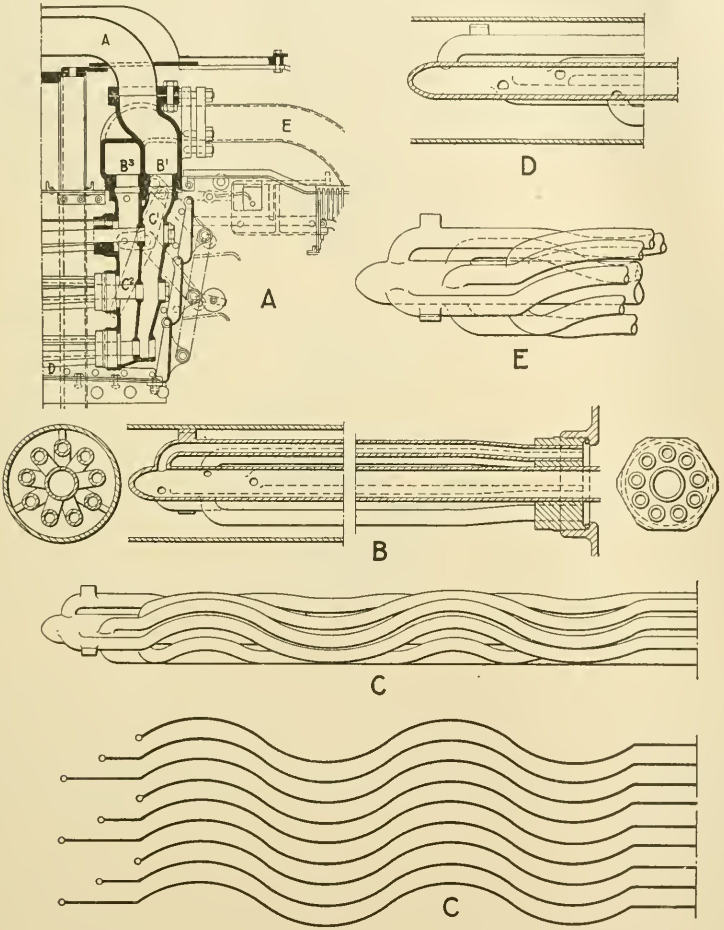

Fig. 9 Mestre Squirrel Cage Superheater

convenient distribution of the metal in the mass of gases passing through the respective flue. The wave or helical shape of the outside pipes produces an effective mixing of the gases which helps the exchange of heat between the gas and steam without impeding the draft in the flue, the latter being due to appropriate selection of the dimensions of the pipes.

Tests. Four of these superheaters have been installed by the Eastern

Railroad Company (France), three on high-speed, and one on a suburban locomotive. In the case of the first kind, the temperature of superheat, 1.7 km (say 1 mile) after starting, reached 270 deg. cent. (518 deg. fahr.), while under the same conditions it used to reach only 225 deg. cent. (437 deg. fahr.) with a Schmidt superheater (the locomotive was of the 4-6-0, compound, four cylinder type). The tests with the suburban locomotive have shown, that contrary to the general belief, superheating, when used with this kind of apparatus, may be efficient for service with frequent stops. This is due mainly to the great sensitiveness of the squirrel cage superheater, the pyrometer needle showing marked rise of temperature 15 seconds after the opening of the throttle, so that, with two stations 1200 m (0.75 miles) distant from one another, the temperature fell to 290

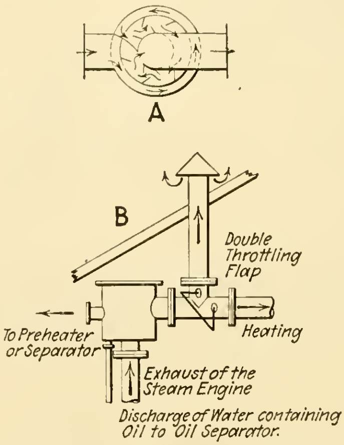

Fig. 10 Heine Combined Centrifugal and Baffle Separator

deg. cent. (554 deg. fahr.) during a 45-seconds stop at the first station, but rose to 342 deg. cent. (645.8 deg. fahr.) by the time the throttle was closed at the entrance to the second station. The Schmidt superheater gave, under the same conditions, from 40 to 50 deg. cent. (72 to 90 deg. fahr.) less superheat. There have been no breaks or leaks in the joint with the squirrel cage superheaters. No complete data of tests are given in the original article.

Heine Separators (*Die Heine-Abscheider, Der praktische Maschinen-Konstrukteur*, vol. 46, no. 9, p. 14 (Triebwerke), April 24, 1913. 1 p., 6 figs. *d*). Description of the Heine separators which are *combined centrifugal and baffle separators.* The gas to be cleaned is carried around one or more times in circles, and deposits its liquid constituents on blades of special shape provided for this purpose. A schematic view of this separator is shown in Fig. 10A, Fig. B showing it as applied to oil separation from steam. This is used also for *drying steam*, or eliminating from it water particles. Similar apparatus are constructed for oil separation from compressed air handled by piston compressors. The original article contains tables giving data as to dimensions and weights of various kinds of such separators.

Measurement of Water in Factories to Determine the Self-Cost of Steam or to Test the Boilers (*Mesure de l'eau dans les usines pour déterminer le prix de revient de la vapeur ou pour les essais de chaudières*, J. Izart. *La Technique moderne*, vol. 6, no. 8, p. 314, April 15, 1913. 1½ pp., 8 figs. *d*). Description of various devices for measuring the feedwater of boilers. The author rejects absolutely all closed water meters, both speed meters (meters with blades) and volumetric (piston meters, etc.), although he considers the latter somewhat more reliable. Only the open meter of the *tipping type* should be used, as they are simple in operation, easy to check, and reliable. The Dégrémont meter (Fig. 11A) consists essentially of a drum 1 divided into three chambers, rotatable about an axis, and making one piece with a three-branch star-shaped body 2. Referring to the figure, the chamber to the left of the drum is being filled, the drum being held in position by the roll 3 and set screw (not shown). The roll 3 is at the end of a lever with a counterweight rotatable about an axis; when the

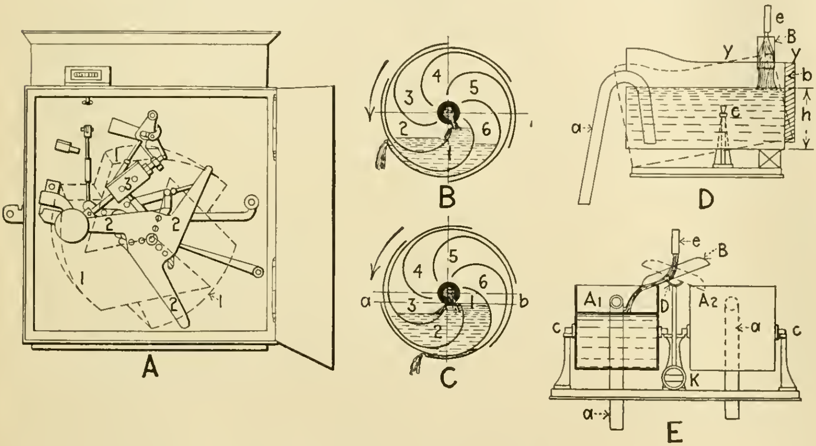

Fig. 11 Boiler Feedwater Meters

amount of water in a compartment reaches a certain predetermined weight, the ray of the star makes the lever tilt by lifting the counterweight, in consequence of which the drum, no longer kept in place by the set screw, starts to rotate, pours out the water from one compartment, and offers the next to the stream of water pouring in, thus recommencing the entire operation. While the drum is tilting, the orifice of the pipe admitting the water is closed by a special stopper.

The Hans Reisert drum meter (Fig. 11B and C) consists essentially of a series of troughs rotating about a central axis through which water is admitted; in filling successively, these troughs cause the rotation of the drum, a special device recording the number of revolutions; as it is the weight of the water that causes the troughs to rotate, the meter actually records the weight of the water. In B water from 6 is flowing out, 1 is full and the overflow is filling 2 which, in filling while 6 is emptying, causes the drum to rotate in the direction of the arrow. In Fig. C is shown a moment of equilibrium: the internal and external edges of the trough 1 pass through the same horizontal line *ab*, and no water flows out;

but since the trough 3 continues to fill, a moment will soon come when the outer edge will be below the inner one, and 1 will begin to empty.

The Leitner meter is shown in Fig. 11D: it consists of two tanks A_1 and A_2 of equal size, and arranged so that they can tilt over the knife edge e; one of the walls of each tank is provided with a syphon a and the opposite wall with a counterweight b of such weight as to balance a weight of water corresponding to the height of level h. As soon as the water exceeds this level the tank tilts and the syphon empties the water, while a special device records the number of tilts. To this same class of meters, the Wilcox meter, fully described in the article, also belongs.

Strength of Materials and Materials of Construction

EXPERIMENTS ON RUSTING OF IRON IN MORTAR AND BRICKWORK (*Versuche uber das Rosten von Eisen in Mörtel und Mauerwerk, Ausschuss für Eisenbeton*, vol. 22, Berlin, 1913, through *Dinglers polytechnisehes Journal*, vol. 328, no. 16, p. 253, April 19, 1913. $\frac{1}{2}$ p. *e*). Resumé of the tests made at the Laboratory for Testing Materials at Gross-Lichterfelde-West, 1907 to 1913, under the direction of Professor Gary. Portland cement mortar, slag portland cement mortar, common mortar, and plaster were the materials used; reinforcing elements were of flat iron, 5.07 cm in section (probably 5.07 qcm, or 0.77 sq. in.), and round iron, 3.5 cm (1.38 in.) and 1.0 cm (0.38 in.) in diameter, set so that pieces stuck out of the mortar, for the grips in sliding resistance tests. The test-pieces were $\frac{3}{4}$, 2 and 5 years old, and had been kept in free air, sweet water, alternately air and sweet water, sea water, bog water and moist sand. The pieces in common and plaster mortar showed weathering even at the beginning of the tests. In all cases rusting began at the iron ends sticking out of the mortar, which must be remembered in considering these test data, since in usual reinforced concrete constructions the iron is fully embedded in concrete. The iron elements were either clear of skin due to rolling, or rusted, coated by red lead, tar or zinc. The iron pieces free from all covering have suffered most from rusting, while a coat of red lead proved to be the best form of protection; the sliding resistance of the red lead coated iron elements proved to be slight at first, but increased with time. Sea water did not appear to attack iron in mortar, probably because protection was afforded by the formation of a porous covering through displacement of lime in the mortar by magnesia from sea water. The original contains a full description of the testing apparatus and methods, as well as complete data of tests, mostly in tabular form.

See also Mechanics for Article on Young's Modulus.

Thermodynamics

NEW TABLES AND DIAGRAMS FOR SULPHUROUS ACID (*Neue Tabellen und Diagramme für schweflige Säure*, Dr. Hýbl. *Zeits. für die gesamte Kälte-Industrie*, vol. 20, no. 4, p. 65, April 1913. 6 pp., 10 figs. *tA*). From the Callendar equation the author derived the following simple equation of state for sulphurous acid:

$$v - v' = \frac{13.24T}{P} - 0.016\left(\frac{273}{T}\right)^4 \qquad [1]$$

where v' is the specific volume of the liquid, within the range used in refrigerating engineering treated as a constant equal to $v' = 0.0007$. The same can be expressed in other ways, e. g., in the form of the Tumlirz equation, such as

$$v=\frac{13.24T}{P}-0.01 \ldots\ldots\ldots\ldots [2]$$

or or that of van der Waals:

$$P=\frac{13.24T}{v-0.006}-\frac{61}{v^2} \ldots\ldots\ldots\ldots [3]$$

The Tumlirz form has a very limited range of application, because, although good for saturated vapor, it gives too small specific volume values for superheated vapor, which is due to the constant used in the equation being too large. The van der Waals equation gives values which agree with the latest experimental data, but is not convenient for practical use because it contains the expression for the specific volume in the third power.

For the functional relation of pressure, temperature and specific volume for

TABLE 1 COMPARISON OF VALUES OBTAINED FROM VARIOUS EQUATIONS FOR VOLUME OF SATURATED SULPHUROUS ACID VAPOR WITH EXPERIMENTAL VALUES

Temperature, Deg. Cent.	Pressure, kg/qcm	Equations			Mollier	Cailletet	Zeuner
		[1]	[2]	[3]			
−30	0.392	0.795	0.811	0.808	.....	0.822	0.794
−20	0.657	0.488	0.500	0.497	.....	0.513	0.503
−10	1.039	0.317	0.325	0.322	.....	0.330	0.329
0	1.578	0.213	0.219	0.216	0.213	0.223	0.221
10	2.321	0.148	0.151	0.150	0.148	0.152	0.152
20	3.320	0.105	0.107	0.106	0.106	0.107	0.107
30	4.635	0.076	0.077	0.076	0.077	0.076	0.076
40	6.335	0.056	0.056	0.056	0.57	0.055	0.055

saturated steam the author uses the values of Cailletet and Mathias, with the last decimal changed, and compares the values obtained from the three above equations with those in the steam tables of Zeuner, Cailletet and Mathias, and Mollier (Table 1). At temperatures above 0 deg. cent. the specific volumes of Mollier are larger, at temperatures below 0 deg. smaller than those of equation [1]; all the other values show the same behavior, viz., first increase with increasing temperature, and then fall with decreasing.

Next comes the behavior of superheated sulphurous acid vapor, for which, with $t=100$ deg. cent. as a basis, the specific volumes indicated in Table 2 are obtained from the three equations, the Tumlirz equation [2] giving the smallest values, while [1] and [3] give practically identical values, the differences in the practically exploited region of temperatures both for the saturated and superheated vapor being less than one per cent either way.

From equation of state [1] and the general heat equation $di=Tds+Adp$, the following equations are derived:

Total heat content: $i=c_p^{\circ}t-1.878 \cdot 10^{-4}\left(\frac{273}{T}\right)^4 P+1.64 \cdot 10^{-6}P+y$

Entropy: $S = c_p^o \ln T - 0.03108 \ln P - 1.5 \cdot 10^{-4}\left(\frac{273}{T}\right)^4 \frac{P}{T} x$

Specific heat at constant pressure: $c_p = c_p^o + 7.51 \cdot 10^{-4}\left(\frac{273}{T}\right)^4 \frac{P}{T}$

where c_p^o is the limiting value of specific heat. According to the latest determinations it increases somewhat with temperature, but so little that for all practical purposes it may be assumed to be constant and equal to 0.32. The last equation indicates that the specific heat c_p increases with pressure, but decreases when the temperature increases, which fully agrees with the latest experimental determinations. The values of x and y are determined in the usual manner from an equation showing the law of variation of the specific heat of the liquid, in this case the Cailletet equation: $c = 0.32 + 0.001172t$, by determining the total hea

TABLE 2 COMPARISON OF VALUES OBTAINED FROM VARIOUS SOURCES FOR VOLUME OF SUPERHEATED SULPHUROUS ACID VAPOR

Pressure, kg/qcm	Equations		
	[1]	[2]	[3]
1	0.489	0.484	0.488
2	0.242	0.237	0.241
3	0.159	0.155	0.158
4	0.119	0.115	0.118
5	0.093	0.089	0.092
6	0.077	0.072	0.076
7	0.065	0.061	0.064
8	0.056	0.052	0.055

content and entropy for some two pressures, and solving the equations so obtained for x and y. It is found that as the temperature rises, x increases and y decreases; y in the expression for the heat content decreases also with the increase of pressure.

From the total heat content is derived the heat of evaporation: $r = i - q$. The external heat of evaporation can be derived either from equation $\psi = AP\,(v - v')$, or from the equation of state:

$$AP(v - v') = 0.03108\,T - 3.75 \cdot 10^{-4} P \left(\frac{273}{T}\right)^4$$

and the inner heat of evaporation from equation

$$\rho = r - AP\,(v - v')$$

In Fig. 12 are drawn the curves of heat of evaporation according to Cailletet, Zeuner, Mollier and equation [1], showing that at low pressures the Zeuner and Cailletet values are the largest, and at high pressures the smallest, while the values from equation [1] lie between them and the Mollier values nearly throughout. On the basis of his new steam tables the author has constructed a heat entropy diagram TS for sulphurous acid, in connection with which *cp*. Table 3. In that diagram the curves of constant temperature are represented by straight

TABLE 3 SATURATED SULPHUROUS ACID VAPOR TABLE

Temperature, Deg. Cent. t	Pressure, Atm. Abs. p	Volume, cbm/kg v	Spec. Weight, kg/cbm γ	Heat Content		Heat of Evaporation			Entropy		r/T	Specific Heat c_p
				Liquid q	Vapor i	Total r	Internal	External	of Liquid S'	of Vapor S		
−30	0.392	0.795	1.258	−9.07	82.73	91.80	84.50	7.31	−0.0352	0.3426	0.3778	0.339
−25	0.512	0.617	1.621	−7.63	83.48	91.11	83.70	7.41	−0.0293	0.3381	0.3674	0.343
−20	0.657	0.488	2.049	−6.17	84.23	90.40	82.88	7.52	−0.0234	0.3339	0.3573	0.346
−15	0.831	0.391	2.558	−4.67	84.97	89.64	82.02	7.62	−0.0175	0.3299	0.3474	0.350
−10	1.039	0.317	3.155	−3.14	85.70	88.84	81.13	7.71	−0.0117	0.3261	0.3378	0.355
−5	1.286	0.259	3.861	−1.59	86.41	88.00	80.21	7.79	−0.0059	0.3225	0.3284	0.359
0	1.578	0.213	4.695	0	87.10	87.10	79.23	7.87	0	0.3190	0.3190	0.363
5	1.921	0.177	5.650	1.61	87.77	86.16	78.22	7.94	0.0059	0.3158	0.3099	0.368
10	2.321	0.148	6.757	3.26	88.41	85.15	77.15	8.00	0.0117	0.3126	0.3009	0.374
15	2.785	0.124	8.065	4.93	89.01	84.08	76.03	8.05	0.0175	0.3094	0.2919	0.379
20	3.320	0.105	9.524	6.63	89.57	82.94	74.84	8.10	0.0234	0.3065	0.2831	0.384
25	3.934	0.089	11.236	8.37	90.08	81.71	73.56	8.15	0.0293	0.3035	0.2742	0.389
30	4.635	0.076	13.158	10.13	90.52	80.39	72.20	8.19	0.0352	0.3005	0.2653	0.395
35	5.432	0.065	15.385	11.92	90.86	78.94	70.72	8.22	0.0410	0.2973	0.2563	0.401
40	6.335	0.056	17.857	13.74	91.08	77.34	69.09	8.25	0.0469	0.2940	0.2471	0.408

lines parallel to the axis of entropy. The curves of constant entropy (adiabatic curves) are represented by straight lines parallel to the axis of temperatures; the curve of constant pressure within the region of wet vapor by straight lines parallel to the axis of entropy, which could be done because, at constant pressure, the variation of state is identical with that of temperature. Within the region of superheat, however, they are logarithmic curves, because at constant pressure the amount of heat brought in is $dQ = c_p dT$, and consequently the increase of entropy, at constant pressure and assumed average constant specific heat c_p, is for variable superheat, between the initial and final state:

$$\int \frac{dQ}{T} = c_p \int_T^{T_1} \frac{dT}{T} = c_p \ln \frac{T_1}{T}$$

These curves are drawn smooth. The curves for constant total heat i are drawn in broken line, while the curves for constant specific volume v are dotted. In the

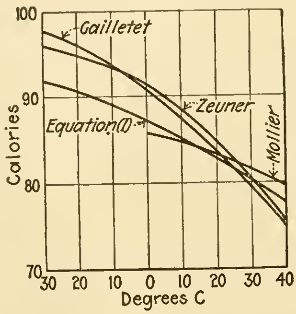

FIG. 12 HEAT OF EVAPORATION CURVES FOR SULPHUROUS ACID

region of wet vapor the specific volume for various pressures may be derived from the equation $v = v' + xw$, and then the entropy from

$$S = \sigma + x\frac{r}{T}.$$

In the region of superheat recourse must be had to the equation of state for superheated vapor, from which, for various pressures, first the temperatures T_1 and then the entropies are calculated.

The curves for constant specific quantity of steam x are obtained by calculating from equation

$$S = \sigma_x + x\frac{r_x}{T_x}$$

the entropy for various pressures, but the same amounts of steam. The construction of these curves is simple: all that is required is to divide into equal ratios the sections r/T.

In conclusion the author gives two examples showing the use of this entropy diagram.

Miscellanea

PROFIT SHARING (*La participation aux bénéfices*, M. Bellom. *La Technique moderne*, vol. 6, no. 9, p. 329, May 1, 1913. 5½ pp. *cd*). Brief description and analysis of various methods of profit sharing in modern industrial establishments,

with reference mainly to the practice of Continental Europe. The material is taken from the most part from the publications of the French Society for the Practical Study of Profit Sharing by Employees.

Reply to a Criticism of the Taylor Sysyem (*Reponse a une critique du système Taylor*, H. Le Chatelier. *Le Génie Civil*, vol. 62, no. 26, p. 514, April 26, 1913. 1 p. *c*). The author, a well-known metallurgist and member of the French Academy of Sciences, disagrees with Admiral J. Edwards' criticism of the Taylor system. To the objection that the installation of the Taylor system is costly, he replies that a modern battleship is more costly than a pirogue of a savage, and still battleships and not dug-outs are built. The Taylor system is costly, but its advantages are great. In the admiral's statement that "in naval arsenals quality and not quantity must be the main standard of production," he sees a contempt of the problem of cost common to government officials in all countries, a point of view which can be approved neither with regard to the tax-payer's rights, nor that of military efficiency. With the same amount of money, and a reduction of cost of 10 per cent, eleven battleships can be built where only ten were possible without the reduction. The Taylor system does not lower the quality of production, since a better organization is conducive both to improvement in quality and increase of volume of production. In France the shops which have adopted the Taylor system are unquestionably in the first rank as far as the quality of their products is concerned. The next objection to the Taylor system is that with its introduction salaries do not increase as rapidly as production. The author says that there is no reason why they should; no extra efforts or longer hours are demanded from the workmen, and in addition the costly organization connected with the introduction of the system has to be paid for; the 25 to 75 per cent increase of salaries which usually follows the introduction of the new system is really more than what the workmen are entitled to. The author also fails to see the force of Admiral Edwards' objection shared by him with some labor leaders as to the use of the stop-watch. No workman objects to being timed by a stop-watch when running a race or in a bicycle competition, so why should he do so when at work? The Admiral says further that the Taylor system involves such a strain on the part of the workman as to be harmful to his health. If it does, that only means that the system applied has nothing to do with Taylor whose system has for its object to increase the production without increasing the effort on the part of the workman. That some workmen may overwork under the Taylor system, just as they do now, is possible, but has nothing to do with the principles of scientific management, except in showing their unsatisfactory application. Can one deny that Mr. Gilbreth with his arrangement of placing bricks on movable scaffolds, so as to dispense with the constant stooping of the workman to pick up bricks, lessens his effort?

There are, however, two difficulties in connection with the Taylor system which the author recognizes: (*a*) to have in the shops the perfect discipline essential to the operation of this system. In ordinary shop management some lack of discipline is not as important as in an organization where a large outlay is made for planning, and will become a dead expense unless this planning is followed out; and (*b*) to find men willing and able to carry this system into practice, engineers with a scientific spirit, knowledge of both the theory of their trade and the practice of the manual operations by which it is carried on, and at the same time with that knowledge of the psychology of the workman which would allow

them to get the men's confidence in the first ten words of a conversation. The technical schools give a training diametrically opposite to those requirements, by laying the main emphasis on scientific methods and by but little appreciating the value of actual industrial processes.

Improved Vacuum Gage in Technically Applicable Form (*Ein verbessertes Kompressionsvakuummeter in technisch brauchbarer Ausführung*, B. Thieme. *Elektrotechnische Zeitschrift*, vol. 34, no. 17, p. 469, April 24, 1913. 1 p., 5 figs. *d*). Description of the MacLeod vacuum gage as improved by Reiff for the measurement of high vacua such as occur in incandescent lamps. The technical applicability of the apparatus lies in the fact that, although nearly 4 ft. long, it has no movable glass parts, and can therefore be handled with comparative ease.

Supplementary References

Stresses Produced in Materials by Riveting (*The Journal*, February 1913, p. 339). Cp. also *The Compressive Forces Required to Form Rivet Heads*, by Earl D. Hay and Wm. L. Edwards in *The Rose Technic*, March 1913, p. 173.

Tests of Autogenous Welding (*The Journal*, December 1912, p. 2090). For another account of the same series of tests see *Essais sur les soudures autogènes in Revue de Métallurgie*, vol. 10, no. 3, P. (Extraits) 78, March 1913, abstracted from *Bulletin de l'Association Lyonnaise des propriétaires d'appareils à vapeur*, XXXV, 37.

Rincker-Wolter Gas Producers (*The Journal*, November 1912, p. 1881). Cp. *Carburcting with Tar*, *The American Gas Light Journal*, vol. 98, no. 13, p. 201, March 31, 1913.

Oddie-Simplex Pumps (*The Journal*, May 1913, p. 902). For description of same cp. *Revue industrielle*, vol. 44, no. 2081/16, p. 217, April 19, 1913.

On the Realization of High Angular Speeds (*The Journal*, March and May 1913, pp. 533 and 893). Cp. paper by the same author, M. Leblanc, *Machines rotatives à très grande vitesse in Mémoires de la Société des Ingénieurs Civils de France*, February 1913, p. 171.

The Equivalent Opening of a Ventilating System (*The Journal*, April 1913, p. 692). Cp. an abstract of the same article in *The Engineering Review* (London), vol. 26, no. 10, p. 366, April 15, 1913. This abstract contains the curves of fan efficiencies omitted in the abstract in The Journal.

Storage of Inflammable Liquids, Martini and Hüneke System (*The Journal*, February 1912, p. 294). Full description of this system in *Braunkohle*, vol. 12, no. 3, p. 35, April 18, 1913.

MEETINGS

BOSTON MEETING, APRIL 25

A meeting of the Boston Society of Civil Engineers, the American Institute of Electrical Engineers, and of The American Society of Mechanical Engineers, under the auspices of the Institute, was held in the Lowell Building of the Massachusetts Institute of Technology, on Friday evening, April 25. A paper on the Delivery and Handling of Freight at the Boston Freight Terminals, by Dr. Harold Pender, H. F. Thompson and C. P. Eldred, was presented. This paper is based on a series of studies of the conditions prevailing at the local freight terminals, with reference to possible improvements. A number of slides were presented showing the distribution of business throughout the day, bringing out strikingly the pronounced "peaks," at inbound houses in the morning and outbound houses in the later afternoon, and illustrating the resulting congestion. The movement of teams of various classes was analyzed with respect to time spent in yards, at warehouses and on the street, and the proportion of time in the yard spent in various ways, such as inquiry, searching, loading, etc., was investigated. The increased efficiency obtained by certain changes introduced as a result of these studies was also shown.

A number of railroad men were present at the meeting and an animated discussion followed the presentation of the paper.

CHICAGO MEETING

The members of the Chicago Section held a meeting at the City Club on May 7. A dinner preceded the business meeting, at which about 77 members and guests were in attendance. P. M. Chamberlain, chairman, called the meeting to order, announcing that its purpose was a better mutual acquaintanceship among the membership, the social features being more in evidence than at previous gatherings. A committee to care for the work of the coming season was elected, consisting of P. P. Bird, C. R. Birdsey, Wm. B. Jackson, A. W. Moseley and C. W. Naylor.

The chairman then introduced Captain Robert W. Hunt, Past-President of the Society, who talked on the Society's Founders. He dwelt most entertainingly on the early years of the Society's life and told about the men who had to do with its organization, relating many interesting incidents in connection with its formation. Captain Hunt's personal acquaintance with all of those who were active in the Society's affairs during its first years gave his remarks a personal quality which added to their interest.

The next speaker, Philetus W. Gates, president of the Hanna Engineer-

ing Works, and a former vice-president of the Society, told, under the title of Early Machine Shops of Chicago, of the experiences of his father and himself in the early days of machine shop practice in that city. His father started the first machine shop there and Mr. Gates' remarks were enhanced by personal experience with conditions.

George M. Brill, a former vice-president of the Society, then gave an account of a trip to Brazil which he had recently made, describing the immense natural resources of South America and the cities which he had visited.

STUDENT BRANCHES

COLUMBIA UNIVERSITY

The annual business meeting for the election of officers of the Mechanical Engineering Society of Columbia University was held May 9 and the following were elected: Frank B. Schmidt, chairman; William Harvey, vice-chairman; W. L. Garrison, treasurer; Harold F. Allen, secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On April 13 the Mechanical Engineering Society of Massachusetts Institute of Technology held their annual banquet at the Boston City Club. The officers elected for the coming year were as follows: W. H. Treat, chairman; W. E. Lucas, vice-chairman; L. L. Downing, secretary; F. P. Karns, treasurer, and R. L. Parsell, F. G. Burinton, W. H. Wilkins, governing committee. The rest of the evening was given over to a general jollification.

On April 25 J. F. D. McDonald of the International Engineering Company addressed the society on Modern Boiler Making Practice. His lecture was illustrated with lantern slides.

On May 3 Charles T. Main, Mem.Am.Soc.M.E., spoke on The New Power Plant of the Pacific Mills at Lawrence, Mass.

On May 5 Frank W. Reynolds, Mem.Am.Soc.M.E., spoke on the subject of The Modern Cotton Mill. The lecture was illustrated with many lantern slides.

F. B. Perry, Mem.Am.Soc.M.E., spoke on The Individual Drive, on May 9. The use of over one hundred lantern slides and Mr. Perry's long experience in the mill department of the General Electric Company made the lecture a particularly valuable one.

OHIO STATE UNIVERSITY

The cause of education has been advanced by the magnificent way in which the students of the Ohio State University met the emergency conditions during the recent flood. Both public and private acknowledgments have been received, and laboratory proof furnished that public education is a good investment for the state, by the intelligence, leadership and efficiency displayed by the men students in building boats, rescuing people from second-story windows, transporting food, clothing and medicines, rescuing property, shoveling mud after the subsidence of the water and putting life, good cheer, and hopefulness and spirit into many people.

PENNSYLVANIA STATE COLLEGE

The motive power section of the Pennsylvania State College Student Branch was addressed by C. E. Barba, assistant engineer for the Pennsylvania Railroad, on April 18. The subject was Railroad Wrecks, their Causes and Prevention. The speaker is in charge of the design of rolling stock for the Pennsylvania Railroad at Altoona, Pa., and he has for many years made a study of this subject with the idea of correcting car and truck design to prevent accidents. He thought the matter of car inspection quite as important as the design in the prevention of wrecks.

John Calder, Mem.Am.Soc.M.E., addressed the faculty and students on April 28, at both a morning and afternoon session, on the subject of Business Organization.

At a meeting held May 6 the following officers were chosen for the coming year: H. L. Swift, chairman; C. F. Kennedy, vice-chairman; Homer L. Hughes, secretary; R. B. Rudy, treasurer. Following the election papers on the Diesel Engine by A. L. Foell, and on Steam Turbines by H. L. Hughes, were read. Each discussed the cost of installation and operation of the respective prime movers as compared with other machines of the same class.

UNIVERSITY OF CINCINNATI

On April 18, Parker H. Kemble, Mem.Am.Soc.M.E., delivered an illustrated lecture on The Development of the Automobile from 1600 to 1896. His lecture was splendidly illustrated with a very complete set of lantern slides.

UNIVERSITY OF ILLINOIS

At a meeting of the Student Branch of the University of Illinois on April 18, Mr. Dumonosque, of the mechanical engineering department of the university, gave a paper on the Production of Oil Gas. The talk covered the development of the present apparatus used in the process, and the theory underlying it. A general discussion followed in which the cost of production, heat value and the composition of the gas was brought out.

On May 2, Prof. G. A. Goodenough, Mem.Am.Soc.M.E., gave an account of What Mechanical Engineers Do. A discussion of the nature of the positions now filled by the university's graduates followed the address.

UNIVERSITY OF NEBRASKA

On May 6 the officers for the coming year were elected; they are as follows: A. A. Luebs, chairman; George W. Nigh, secretary; A. V. Larson, treasurer; C. A. Hauptman, reporter.

YALE UNIVERSITY

On April 23 the mechanical and electrical engineering students held a joint meeting at which W. L. Morse, terminal engineer of the New York Central Railroad, delivered an interesting lecture on the Grand Central Terminal Improvements in New York. Lantern slides were used to illustrate the paper.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

Abhandlungen und Berichte über technisches Schulwesen. vol. 1–4. *Berlin, 1910–1912.* Gift of Deutschen Ausschusz für Technisches Schulwesen.

Die Abhitzkessel, F. Peter. *Halle a. S., 1913.*

Air Compression and Transmission, H. J. Thorkelson. *New York, McGraw-Hill Book Co., 1913.*

This work is based on lectures delivered by the author to his classes at the University of Wisconsin. It gives adequate theoretical treatment, and a description of the most modern machinery applied to ventilation, power transmission and refrigeration.

Beitrag zur Berechnung der Kreuzweise bewehrten Eisenbetonplatten und deren Aufnahmeträger, A. Danusso. *Berlin, 1913.*

Die Blechbearbeitungs-Technik, F. Georgi and A. Schubert. *Leipzig, 1913.*

Circulation of Water in Steam Boilers. From a Lecture by Geo. H. Babcock, delivered at Cornell University, February 1890. *New York, 1912.* Gift of E. T. Copeland Co.

Detroit River Tunnel, Alternate Design for, by the McBean Method. 1 sheet. Gift of D. D. McBean.

Deutscher Ausschuss für Eisenbeton. pt. 5–8, 10–11. *Berlin, 1910–1911.*

Elektrisch betriebene Aufzüge, ihr Wesen, Anlage und Betrieb, P. Schwehm. *Hannover, 1901.*

Die Fördertechnik. vols. 2–4, 1909–1911. *Berlin, 1909–1911.*

Engineering Thermodynamics, C. E. Lucke. *New York, McGraw-Hill Book Co.* 1912.

The whole book is divided into three parts. The first three chapters deal with work without any particular reference to heat, the second two with heat, without any particular reference to work, and the last with the relation between heat and work. Of the first three the second chapter deals with the determination of the work done in compressor cylinders and the third, the available work in engine cylinders, in terms of all the different variables that may determine the work for given dimensions of cylinders or for given quantities of fluid. Chapter five treats heating by combustion, fuels, furnaces, gas producers and steam boilers, gas engines and refrigerating machinery being left to the last chapter. A large number of tables and diagrams are given in the text, which makes the book a valuable source of reference. A somewhat novel feature of the book is that nearly all formulae are written out in words in addition to or instead of expressing them in symbols. This saves a great deal of time and labor in hunting up the meaning of symbols by one who is not familiar with the notification adopted in the text; it is also a help to many engineers who do not possess the ability to visualize the physical meaning of an engineering formula expressed analytically, and have to have it translated to them in plain language before they can see what it is about. As Professor Perry said about twenty-five years ago, there are many engineers who

skip a page when they see on it a sign of integration, and for them (and they may be very good engineers otherwise) Professor Lucke's system of writing out the formulae, especially the somewhat complicated thermodynamic relations, will be certainly welcome. The book contains a large number of examples, both worked out in full and left in the state of problems to be solved by the reader.

Gas, Petrol, and Oil Engine, Dugald Clerk and G. A. Burls. vol. 2. *London, New York, 1913.*

Heating and Ventilating Buildings, R. C. Carpenter. ed. 5. *New York, 1911.*

Improvement and Development of the Transportation Facilities of San Francisco, Bion J. Arnold. Report. *San Francisco, 1913.* Gift of B. J. Arnold and J. R. Bibbins.

International Railway General Foremen's Association. Report of proceedings of the eighth annual convention, 1912. *1912.* Gift of association.

Interurban Electric Railway Terminal System for the City of Cincinnati. Report. October 1912. *1912.* Gift of Bion J. Arnold.

Der Kinematograph und das sich bewegende Bild, Carl Forch. *Wien, 1913.*

Konstruktion und Berechnung von Selbstanlassern für elektrische Aufzüge mit Druckknopfsteuerung, Hugo Mosler. *Berlin, 1904.*

Lehrbuch der Baumaterialienkunde, Max Foerster. pt. 1, pt. 2 (1–2), pts. 3–4. *Leipzig, 1903, 1905, 1911.*

Locomotive Catechism, Robert Grimshaw. ed. 28. *New York, 1913.*

Metallographie, W. Guertler. pt. 6. *Berlin, 1910.*

Metropolitan Sewerage Commission of New York. Preliminary Reports on the Disposal of New York's Sewage. VI, VII, February 1913. *New York, 1913.* Gift of commission.

Metropolitan Street Railway System of Kansas City, B. J. Arnold. Report to William C. Hook, on the Value of the Properties. vol. 1. Gift of B. J. Arnold.

Moderne Eishäuser, Trockenluft-, Kühl u. Gefrieranlagen mit Eisbetrieb, Andreas Horstmann. *Cassel, 1912.*

New York Electric Railway Association. Report of the 30th Annual Meeting, 1912. *1912.* Gift of association.

Paving Brick, the Necessity of Uniform Quality. Tests for High-Grade Paving Bricks, J. W. Howard. *1913.* Gift of author.

Recommendations for Proposed Merger Ordinance for Surface and Elevated Railway Properties in the City of Chicago, based upon the February 11, 1907, Ordinances, B. J. Arnold. *Chicago, 1913.* Gift of B. J. Arnold.

Regulation, Valuation and Depreciation of Public Utilities, S. S. Wyer. *Columbus, O., Sears & Simpson Co., 1913.* Gift of author.

This book illustrates modern practice in printing on thin paper, 314 pages and the limp cover have a thickness of only three-eighths of an inch. It can easily be carried in the pocket or an attorney's brief bag. The condensation is followed in principle in the text, which is briefed for the use of busy men. Expressions of opinion are supported by a quotation of authority. There are a valuable bibliography and a very complete index. Engineering data and legal definitions are given in condensed form.

Safety Valve Rating, A. B. Carhart. *Boston, 1913.* Gift of author.

Über Schwerlast- Drehkrane im Werft- und Hafenverkehr, Eugen Schürmann. *München, 1904.*

Sicherheitsapparate von Fördermaschinen, Förster. *Kattowitz, 1911.*

Some Milling Experiments, P. V. Vernon. *Manchester, 1913.* Gift of author.

South Africa, Johannesburg, Mines Trials Committee. Report on an investigation made on various kinds of rock drill steel for the purpose of determining the most suitable steel for use on the Rand. Gift of Mines Trials Committee.

Springfield, Mass., Board of Water Commissioners. 39th Annual Report, 1912. *Springfield, 1913.* Gift of Water Commissioners.

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EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

506 Superintendent of large experience in automobile and Diesel engine construction. Location Indiana.

507 Office manager with mechanical and commercial training. Location Indiana.

509 Assistant to works manager, able to help on design of special devices to plan piping lines, building changes, requisition materials required, carry on investigation of proposed machinery, furnace and other equipment. State experience, age, whether married or single, salary wanted and references. Location Massachusetts.

510 Man with broad experience in the design of high-grade steam power stations. Location Boston.

511 Established firm of efficiency engineers desire to add to their staff, two or three young technical graduates with about one or two years' business experience since leaving college.

514 Industrial engineer desires capable rate-setter.

515 Supervising engineer for management and development of properties. Technical graduate, with ability to handle men, and experienced in operation and repair of all kinds of boilers, elevators, plant work, etc.

MEN AVAILABLE

110 Member, aged 35, graduate of Massachusetts Institute of Technology, three years in charge of work in mechanical engineering in the post graduate department of the United States Naval Academy, wishes to make another engagement after July 1. Thoroughly experienced in engineering, testing and experimental work; broad commercial experience. Fully competent to develop engineering department in new school or to broaden and revise work of an existing department along most modern lines.

111 Junior member, 30 years of age, mechanical engineer, technical education, 10 years' practical experience, in design, construction, operation, maintenance and reorganization of mill, factory, and other manufacturing properties. Wide experience in the superintendance of central power stations, factory extension, mill and reinforced concrete construction work.

Desires position of mechanical superintendent or master mechanic. Particularly experienced in practical efficiency work. At present employed.

112 Mechanical engineer, Member, 31, technical training, now in charge of drafting room and planning department of large manufacturing and repair shops abroad, desires position as assistant manager or efficiency engineer. Can coöperate with and handle men.

113 Junior, 27, married. Now employed but desires to locate with a live, progressive Eastern concern, opportunities for advancement. Technical graduate: machine shop and drafting room experience: executive ability. Full particulars upon application. Best of references furnished.

114 Professor of mechanical engineering in charge of department in a state university desires to change to similar position or to practical work.

115 Technical graduate, age 30 years. Five years' experience in charge of power plant economy and testing work, expert on operation of stokers, boilers, and surface condensers. Familiar with all kinds of power plant apparatus, would like position with company manufacturing condensers, consulting engineer doing power plant business, or as superintendent or assistant superintendent of power for lighting and power company. Best references. Salary $225 per month.

116 Graduate engineer with excellent experience along mechanical and electrical lines with consulting, manufacturing and selling concerns desires permanent position in or near New York. Age 36, at present employed in an executive sales position, but desires to change for a better future and more permanent work.

117 Technical graduate with shop, testing, designing and sales experience in internal-combustion engine line, desires to connect with gas engine concern, or teaching engineering subjects.

118 Technical graduate, age 37, practical mechanic with 15 years' experience in executive and designing capacity in various lines, desires position as superintendent or mechanical engineer.

119 Mechanical graduate, age 35, general experience, mechanical and electrical engineering: matters relating to construction, plant maintenance, machinery, shop and laboratory inspections: engineering specifications, contracts, valuations.

120 Mechanical engineer, operation, maintenance and construction, government, railroad and factory experience. Recently plant engineer.

121 Member, graduate mechanical engineer, open to engagement for teaching mechanical engineering. Six years' experience in charge of the department in a state university.

122 Junior member; married, desires position as superintendent or business manager, preferably with an educational or medical institution. Seven years in present position as assistant manager of an important New York institution. Experienced in employing, organizing, purchasing, planning and supervision of building construction. Also five years of practical engineering experience. Salary dependent upon opportunity. Very best of references.

123 Member, technical graduate, 18 years' experience, at liberty after July 1. Thoroughly conversant with modern machine tools and methods and foundry practice both grey and malleable iron. Last ten years has

systematized shops and processes, installed cost production, routing, piece and premium payment systems with marked reductions in cost. Wishes to obtain position with large concern as general efficiency man, works manager or general superintendent.

124 Student member, age 27, will graduate from Cornell in June 1913, seven years' experience as machinist (prior to, and during summers of college course) wishes to locate in the East or South.

125 Member, technical graduate, 36 years of age, 11 years with last employer, designing and directing installation of power plants, railroad shops and heating and ventilating systems, desires similar work in New York City, or elsewhere in the East. Salary expected $250.

126 Junior member, Massachusetts Institute of Technology, seven years' experience, drafting room, office, shop and traveling sales department, would like position as assistant to chief engineer or manager of manufacturing plant in East. Accustomed to handling men, drawing up contracts, estimating, etc. At present employed.

127 Student member, 28 years of age, graduate of the University of Illinois, six years' experience in machine shops with wide range of work. Well versed in modern shop methods and management and can handle men. Desires position as foreman of college machine shop.

128 Technical graduate, age 27, four years' general experience in steel mill engineering and maintenance, desires position as experimental engineer or master mechanic. At present employed. Best of references.

129 Member of the Society also fellow A.A.A.S., Cornell graduate, desires a change. Experience: 10 years shop, 6 years drafting and other engineering work, and 6 years engineering teaching. Has taught almost all mechanical engineering subjects including lecture, recitation, laboratory, and drafting room work. Executive ability. Past three years in charge of machine design and construction.

130 Technical graduate, Junior member, 10 years' practical experience; at present engaged as superintendent of manufacturing concern, desires to make change to larger field. Experience covers design and manufacture of interchangeable parts and machinery, tools, jigs, and fixtures for increasing production, etc. Good references.

131 Connection with a sales or executive department desired by student member upon graduation from mechanical engineering course in June. Has had business and shop experience.

132 Member, technical graduate, 10 years' experience as power plant specialist and efficiency engineer, desires connection with large manufacturing concern or firm of bankers, controlling and operating plants. At present employed. Excellent references.

133 Technical graduate, age 37, practical mechanic with 10 years' experience in executive capacity, mill engineering, power generation, transmission, etc., desires position as factory engineer or works manager with progressive concern in New England.

134 Member, technical graduate, 18 years' experience in shop, designing and layouts, testing materials and machines, now teaching, wishes to locate in South or East, preferably with consulting engineer or technical school.

135 Member desires position as manager of small shop. Will consider position as sales manager, chief engineer, chief draftsman or salesman.

136 Yale graduate. Experienced as assistant and mechanical engineer in design, supervision and construction of tube and sheet metal mills, power plants, etc. Desires position in charge of power plant construction with public service corporation or engineering firm.

137 Stevens graduate 1912. Experience in construction work installation and charge of safety devices.

138 Associate, age 35, with 17 years' broad experience in drawing-rooms on civil, structural and mechanical work, desires a position of responsibility, in or near Philadelphia. Experience on furnaces, steel plants, mill work, power plants, chemical apparatus, gas plants, coke ovens, etc.

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Columbia University	Nov. 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	Dec. 4, 1908	R. C. Carpenter	S. D. Mills	D. S. Wegg, Jr.
Lehigh University	June 2, 1911	P.B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. F. Durand	C. T. Keefer	K. J. Marshall
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	W. H. Treat	L. L. Downing
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan.10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Penna. State College	Nov. 9, 1909	J. P. Jackson	H. L. Swift	H. L. Hughes
Poly. Inst. of Brooklyn	Mar. 9, 1909	W. D. Ennis	B. L. Huestis	A. Bielek
Purdue University	Mar. 9, 1909	G. A. Young	L. L. Savage	W. B. Stephenson
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Iowa	Apr.11, 1913	R. S. Wilbur	Geo. J. Keller	L. Garmes
State Univ. of Kentucky	Jan.10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C.Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	Dec. 3, 1911	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
Univ. of Arkansas	Apr.12, 1910	B. N. Wilson	M. McGill	C. Bethel
Univ. of California	Feb.13, 1912	Joseph N. LeConte	J. F. Ball	G. H. Hagar
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	C. W. Lytle	A. O. Hurxthal
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	C. A. Schoessel	E. M. McCormick
Univ. of Kansas	Mar. 9, 1909	F. W. Sibley	E. A. Van Houten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	E. H. Bigelow	O. H. Davis
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	W. P. Jesse	R. Runge
Univ. of Minnesota	May12, 1913			
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. K. Fitch	J. W. Griswold
Washington University	Mar.10,1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct.11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE JOURNAL

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INDEX TO THE JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JANUARY-JUNE 1913

INDEX TO THE JOURNAL, JANUARY-JUNE 1913

NOTE: Items appearing in The Journal as Society Affairs, have the month and page number given. Where the list of discussors of a paper is given, the list appears under the straight title of the paper. Papers published in The Journal previous to January, discussion of which was published during January to June, are indicated by the month, followed by 1912. All papers, reports, etc., of the Gas Power Section appear under the heading Gas Power Section.

EXTRACTS FROM THE BOOK OF THE

Multi-stop and Double Turners

FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six holes at the rear of the turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

FIG. 1

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

HARTNESS FLAT TURRET LATHE

MAILED ON REQUEST

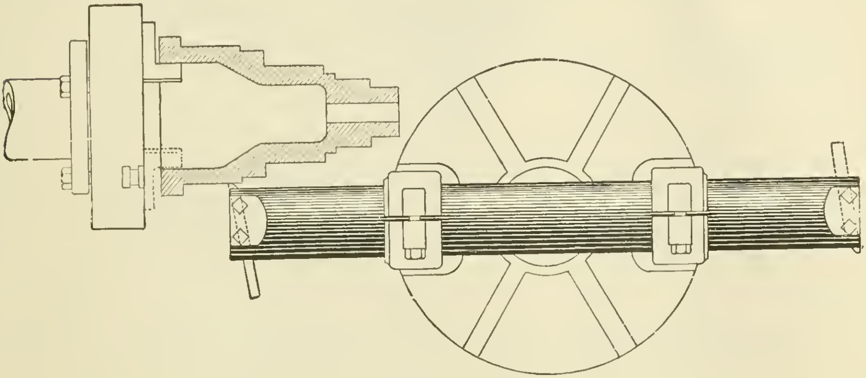

FIG. 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

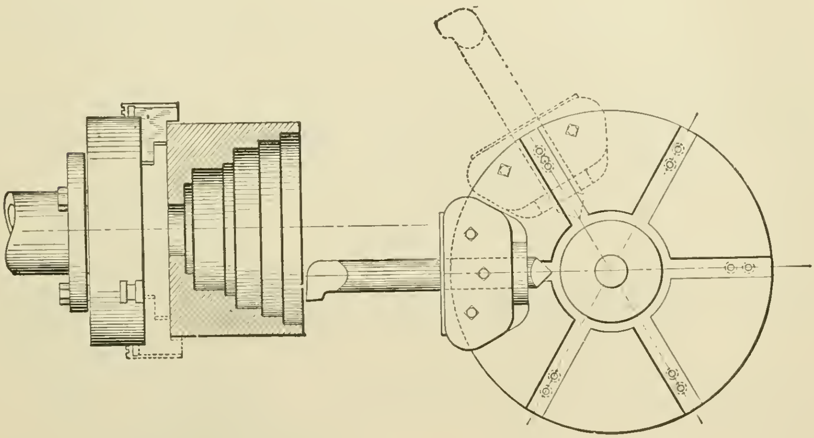

FIG. 3

HAMILTON CORLISS

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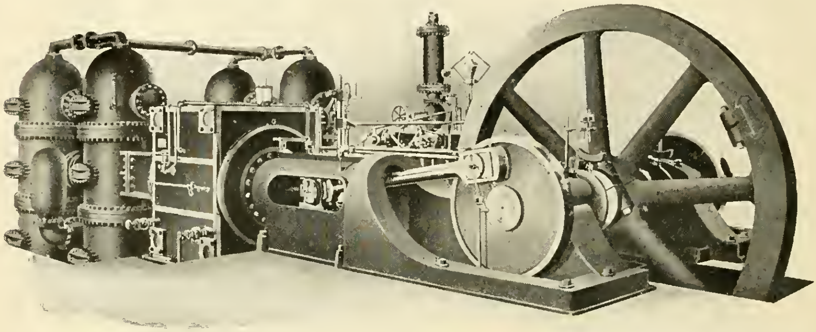

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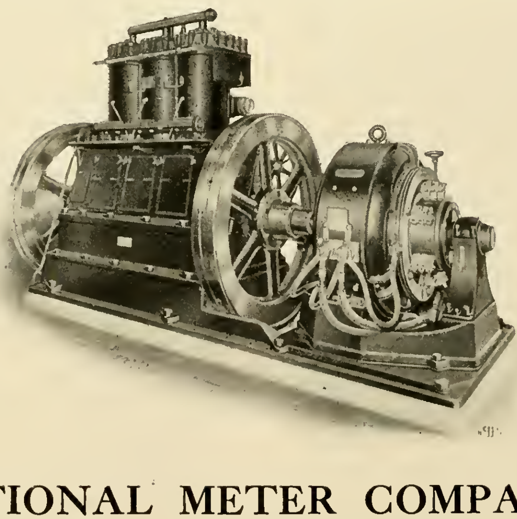

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ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE

JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JULY 1913

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS • 29 W. 39 ST., N.Y. •

35 CENTS A COPY $3 A YEAR

MEETING IN GERMANY: JUNE 21–JULY 8

A NEW METHOD OF ELECTING MEMBERS

In order to provide against unnecessary delays in admitting to the Society those well qualified for membership, a new method of handling applications was adopted at the recent Spring Meeting.

Candidates for membership are posted in the issue of The Journal following the receipt of their applications. A period of 40 days is given in which members may advise the Secretary of any objection they may have to the election of any individual (see page 5).

At the expiration of the time for which an applicant is posted the Membership Committee meet to consider each application and make recommendation to the Council as to the grade to which candidates who receive their favorable consideration shall be assigned.

A list of the candidates, together with the recommendations of the Membership Committee, is then submitted to the Council for vote by letter ballot. Two negative votes prevent an election to membership.

This method of handling applications for membership makes it possible to pass upon well qualified candidates in from 70 to 90 days at any season of the year.

Members are requested to scrutinize with the utmost care the lists of applicants published in The Journal each month, in order that they may advise the Secretary of any candidate whose eligibility for membership is in any

way questioned. All correspondence in regard to such matters is strictly confidential.

COMMITTEE ON INCREASE OF MEMBERSHIP

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JULY 1913 VOL. 35 No. 7

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 JULY 1913 NUMBER 7

The Society's stock of Volume 6 of Transactions is entirely exhausted and to supply urgent demands copies will be purchased at five dollars per volume if delivered at the Society rooms prepaid and in good condition.

MEETING IN GERMANY

The trip to Germany so long planned for and so greatly anticipated by those who were able to accept the invitation of the Verein deutscher Ingenieure, began on June 10 with the sailing of the Victoria Luise from the Hamburg-American Line dock in Hoboken. News of its safe arrival in Hamburg on the afternoon of Thursday, June 19, is reported in a cable received a short time ago. The voyage was most enjoyable, sunshine and smooth seas favoring the travelers all the way and the many social features making the ship's company resemble a yachting party rather than an ordinary ocean trip. About 250 members and guests composed the German party, making up by far the greater portion of the passenger list. Fifty members and guests joined the party upon its arrival in Hamburg.

The Victoria Luise is one of the largest and finest cruising boats in the world, carrying only first-class passengers, and is admirably adapted to the needs of a large party. Immediately upon its arrival in Hamburg, it was scheduled to convey Kaiser Wilhelm and his royal party to the yacht races at Kiel.

Letters written just before the close of the trip across and

mailed at Cherbourg have been received just as The Journal is on the press and some account can here be given of the various events on shipboard. The first three days were fair with smooth seas and quite warm temperature in the gulf stream, and the succeeding days brought a freshening breeze with a somewhat choppy sea, though not of a nature to cause discomfort.

The Entertainment Committee, Prof. Arthur M. Greene, Jr., chairman, had arranged so full a program, to which the ship's company in general were invited, that almost every hour of the passage was eventful. Indeed, the person must have been indifferent who could long remain in his steamer chair, oblivious to the jollity in progress.

The first gathering was held on Wednesday evening, the second day out, when the ship's officers and the present and past officers of the Society received the company, after which was the all-important function of swearing in the special and secret police, with Frank B. Gilbreth as chief. In his speech of acceptance, Mr. Gilbreth reverted for a moment to thoughts of members left on the home shore, and proposed sending a congratulatory wireless to James M. Dodge, who on the day previous had received the degree of Doctor of Engineering at Stevens Institute of Technology.

Unfortunately the chief's reign in the interest of good order was somewhat checked on Friday evening, when he was himself arrested on several serious charges and brought before the court, Worcester R. Warner, presiding judge, for mock trial. One of the indictments was that he had permitted passengers to exceed the speed limit of twelve knots an hour on the deck in the early morning. Several of the leading engineering experts of the country were called upon to testify and much scientific evidence was educed. The jury, however, disagreed, but since they believed that some one should be convicted, the chief's deputies were sentenced instead.

The strongest of the entertainment features were the lectures given on different evenings, bearing upon the land trip to come. The first, by Henry Hess, traced the history of the German Empire and the steps which have led to the unification of the states, and to the present industrial activity. By several pertinent examples, he showed his hearers that much that was called modern in engineering was really perhaps centuries old.

A second lecture on German Art, by Prof. H. E. Clifford, gave in a delightful manner a summary of the work of German artists,

contending that Germany has recently developed no characteristic art in paintings, but instead has easily become the leader in the world's music.

The third lecture, by Worcester R. Warner, on German Cities, took the audience through the cities of the scheduled trip by the aid of lantern slides and gave figures upon their growth and the commercial conditions of Germany. The concluding lecture on the German Educational System, by Prof. C. R. Richards, was arranged for Wednesday evening, June 18, and had not yet been given when the letter was written.

On Monday, June 16, the twenty-fifth anniversary of the accession of Emperor Wilhelm II to the throne was celebrated throughout Germany, and in honor of the occasion, Captain M. Meyer of the Victoria Luise gave a Silver Jubilee dinner on Sunday night, June 15. The dinner was excellent, and the saloon handsomely decorated for the occasion. The captain in a brief speech spoke feelingly of the three emperors, Wilhelm I, Frederick, and Wilhelm II., and said that Germans are everywhere and would do homage throughout the world to the present emperor.

Prof. Wm. H. Carpenter, vice-president of Columbia University and president of the Germanic Society of America, who was a passenger on the ship, appropriately gave the response. He dwelt on the supposed warlike tendencies of Wilhelm II, his love of pomp and ceremony, and of the fears of the world that it meant war and a military rule when he came to the throne. Instead, his strengthening of the military arm of Germany has been for the purpose of maintaining German unity and fostering industrial development under the assurance of peace. He contrasted the industrial activity of today with the lack of it thirty-five years ago when he himself was a German student.

This dinner, the regular "Captain's dinner," which came later, and an admirable Sunday service, all added pleasure to the company's pastime. Numerous other events, sports, games and contests and even a baby show aroused an interest which would not be possible on land where there are conflicting and greater outside interests. Perhaps as much interest was felt in the Wireless Contest as in any one thing. This required the writing of a message of twenty words in rhyme, and from the 85 entries two were declared to be equally good, so that the judges could not decide between them. The winning gentleman withdrew in favor of the lady, who was permitted as a reward to send a gen-

uine message of ten words. Two dances were given during the trip, one of them a cotillion.

The best evidence of the happy frame of mind of all concerned is contained in the following resolution which those of the company not members of the Society presented to the party:

"As passengers on board this ship,
We thank the engineers,
For all they did to make this trip
The pleasantest in years.

"They helped us pass the time away
And made dull hours short,
With games and contests, dance and play,
And every kind of sport.

"Whoe'er we are, where'er we sit,
Or what our name may be,
They gave us all a hearty bid
To share their jollity.

"Full many of the passengers
Joined in their cheerful ranks,
And now we place our signatures
Beneath this vote of thanks."

At Plymouth, where the ship arrived on Wednesday morning, at five o'clock, representatives of the Verein deutscher Ingenieure came aboard to greet the Society. These were E. Kroebel, Dr. I. Milsen, Prof. G. Frasch, and Prof. Conrad Matschoss. The Hamburg-American Line was also represented by Aug. Joseph, H. Schulte-Pelkum and Carl H. Lody.

A complete account of the meeting abroad will appear in subsequent issues.

KELVIN MEMORIAL WINDOW

The Kelvin Memorial Window which has been erected in Westminster Abbey in memory of Lord Kelvin, the designer of the first successful apparatus for ocean cables, will be unveiled on July 15 with a suitable dedication ceremony. The Society which is one of the eighteen engineering organizations here and abroad participating in this memorial will be represented at the unveiling, some of the members in attendance at the German meeting going to England for the purpose.

The general design of the window is of the same character as that of the Baker Window near which it has been placed, erected several years ago.

APPLICATIONS FOR ELECTION

The Membership Committee have received applications from the following candidates. Any member objecting to the election of any of these candidates should inform the Secretary before August 15, 1913:

Anderson, Ross, Bridgeville, Pa.
Beckwith, Henry C., Portland, Ore.
Black, George, Troy, N. Y.
Brinley, Charles E., Philadelphia, Pa.
Brock, Clarence A., Worcester, Mass.
Bryce, Richard M., Easton, Pa.
Buckingham, Earle, Hartford, Conn.
Buckwalter, Tracy V., Altoona, Pa.
Burling, Herbert S., Summit, N. J.
Bushnell, Leonard T., Seattle, Wash.
Dargert, Henry D., Salamanca, N. Y.
Dufty, Arthur, Lafayette, Ind.
Ellis, Henry G., Ansonia, Conn.
Fitzsimmons, James C., San Francisco, Cal.
Frink, Gerald, Seattle, Wash.
Gersoni, Louis J., Brooklyn, N. Y.
Givan, Albert, Sacramento, Cal.
Haines, Philip G., Rochester, N. Y.
Heimann, Leopold, Elizabeth, N. J.
Hibbard, Robert L., Leetsdale, Pa.
Howie, Howard Benson, Chattanooga, Tenn.
Keuffel, Carl W., Hoboken, N. J.
Long, L. Guy, Indianapolis, Ind.
Loveland, George E., Palmerton, Pa.
McArdell, Wesley E., Brooklyn, N. Y.
Mitchell, Guy K., Baltimore, Md.
Palmer, Rafael M., San Juan, Porto Rico
Parker, Daniel Holmes, Windsor, Vt.
Peters, R. F., San Antonio, Texas
Porter, Finley R., Trenton, N. J.
Ralli, Victor P., New York
Ruble, Joseph S., Cleveland, Ohio
Schuchart, Theodore, Mülheim, Germany
Sellew, William H., Detroit, Mich.
South, Furman, Jr., Edgeworth, Pa.
Sponsel, John G., Urbana, Ill.
Stratton, Samuel W., Washington, D. C.
Taber, Wm. B., Radnor, Pa.
Waring, Chas. A., Dayton, Ohio
Welchans, Bertram G., Hamilton, Canada
Weld, Alfred O., Winchester, Mass.
Wright, Stanley, St. Louis, Mo.

PROMOTION FROM ASSOCIATE

Nelson, James W., Brooklyn, N. Y.
Wilson, Lester G., Norfolk, Va.

PROMOTION FROM JUNIORS

Coes, Harold V., Boston, Mass.
Montgomery, Stafford, Riverside, Ill.
Swartwout, Everett W., Chicago, Ill.

SUMMARY

New applications	42
Promotion from Associate	2
Promotion from Junior	3
Total	47

CHRONOLOGY OF AVIATION

The Society has received from Mr. Hudson Maxim and Mr. William J. Hammer, a limited number of their very complete Chronology of Aviation, originally prepared for the World's Almanac of 1911, and recently issued in pamphlet form. The data embrace the essential facts relating to aerial progress, giving, in addition to a short historical resumé, tables showing altitude and quick starting and slow speed records, and passenger

carrying records, with accounts of English channel and other over-water flights, cross-country flights, and notable distance and duration flights. There are also statistics relating to accidents and data relative to spherical and dirigible balloons or airships, etc. Of no small interest are the tables giving the most important work of the Wright brothers.

Any member of the Society who is interested in this subject and who would be glad to secure a copy of this interesting brochure, may do so by applying to the Secretary.

THE FIRE HAZARD IN TURBO-GENERATORS

By G. S. Lawler

ABSTRACT OF PAPER

There is great chance that serious fire damage will follow arcing in turbo-generators, due to the large amount of exposed, concentrated, combustible insulation, the large amount of energy usually involved in a short circuit, the large quantity of oxygen supplied with the cooling air and the inaccessibility of the fire.

In addition to the ordinary causes, arcing may occur in turbo-generators due to distortion of stator coils and injury to insulation caused by heavy rushes of current unless reactance is provided to limit the amount of current. Generators provided with sufficient reactance may not give trouble until near the end of their life, when short circuits from ordinary causes may be expected. Most generators are not discarded until after at least one short circuit has occurred.

To reduce the chance of fire damage, it is suggested that exposed coils have non-combustible outer covering, the cooling air be filtered and automatically cut off at time of fire and that at the same time carbon dioxide gas be introduced.

On account of their value and the serious results sometimes occurring when their service is interrupted, it is important that turbo-generators be protected from fire.

THE FIRE HAZARD IN TURBO-GENERATORS

By G. S. Lawler,[1] Boston, Mass.

Non-Member

The chances of electric generators of the older types being seriously injured by fire in the event of some part of the insulation failing is slight. Occasionally arcing will ignite the insulation at some point, but it is seldom that the fire will spread much before it is extinguished. This freedom from fire damage is due principally to the comparatively low speeds, the accessibility of the combustible insulation, and the fact that the machines being of large mass per unit capacity, the insulation is considerably distributed.

2 This condition of practical freedom from fire is reversed in the case of generators of the turbo type, for when a short circuit occurs in one of them there is a great chance that the insulation will be ignited and the machine be badly damaged; in fact such damage has occurred in a number of instances.

3 The chief causes of the increased hazard in the more modern type generators are as follows:

a The volume occupied by this type of machine is very much less for the same capacity than that of the older types of generators, so that the combustible insulation is more concentrated and, therefore, much of it is exposed, even to a slight arc or fire. The covering on the conductors depends greatly for its insulating qualities on the presence of oils or gums of a highly combustible nature. The amount of this combustible insulation on the higher voltage generators is naturally greater than in the low voltage machines.

Owing to turbo-generators having only a few poles the end connections between slots form a large proportion of the total length of conductors, in fact in some

[1] Elec. Engr., Inspection Dept., Assoc. Mut. Fire Ins. Cos., 31 Milk St.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

designs approximately one-half of the coils are outside of the slots. These end connections, one-half being on one side of the machine and one-half on the other, are exposed to fire, and as with a pile of loosely laid sticks, fire will rapidly extend from the insulation on one coil to that on the others.

b Owing to these generators being of exceedingly large capacity in many instances, (one of 30,000 kva. capacity now being constructed) an enormous amount of energy is involved in a short circuit, especially at the instant the short occurs and as the arc is confined in the limited space with the combustible insulation, it would seem impossible for the insulation to escape being set on fire at many points simultaneously.

c The machines are cooled by forcing large quantities of air through the spaces between the conductors. The large and constantly renewed supply of oxygen will hasten combustion when it is once started.

The air is given somewhat of a rotary motion by the rapidly revolving rotor which has the ventilating vanes on it and consequently fire when started will be quickly swept around the exposed insulation.

d The generators are totally encased with the exception of the air inlets and outlets and even these in some designs are under the machines. This construction prevents access to a fire and much valuable time will necessarily be consumed before extinguishing agents can be used effectively. When the field current is cut off, as is necessary in case of short circuit, the only means of bringing the rotor quickly to rest is lost and it will continue to run for a long time after the steam has been shut off. Some machines will run for over an hour. This continued rotation is not conducive to the quick extinguishing of fire, especially when the ventilating vanes are mounted on the rotor.

4 In addition to the possible causes of arcing existing in the case of the older types of generators, the turbo-generator is subject to momentary large current rush at instant of short circuit, even if the short is external to the machine itself, unless means are taken to keep the current within safe limits. The heavy rush of current causes mechanical stresses in the conductors, which in

some cases are severe enough to distort the conductors, especially where outside the slots, and to injure the insulating covering, resulting in a short circuit within the generator itself. In some designs the internal reactance of the machines will permit of the momentary current rush amounting to 40, or possibly more, times the normal full-load current of the machines.

5 The possibility of the conductors being distorted has been reduced in some cases by designing generators with sufficient internal reactance, or by providing external reactance such that the current at the moment of short circuit will not be great enough to damage the generators. Attention has also been given to supporting the stator end connections to prevent their distortion. These means have undoubtedly greatly increased the safety of the turbo-type of generator from possibilities of internal short circuit, but in no way tend to prevent a fire resulting should an arc occur.

6 A short circuit in the rotor will probably not result in a severe fire unless under exceptional conditions. This is also true if the short circuit occurs inside of a stator slot. A short circuit involving a stator coil, however, is more apt to occur at the end of the slot where the conductors are exposed.

7 As asbestos is now used largely for insulating the rotor windings and as these windings are well protected, it is probable that only in cases of severe fire in a machine will the rotor windings be damaged to any extent.

8 While the generators may be free from fires during the earlier portions of their life owing to the proper use of reactances which prevent external troubles seriously affecting the machines, as they get older the ordinary causes of breakdown of insulation are liable to occur and fires result. Probably in most cases generators will not be discarded until some trouble, usually in the nature of a short circuit, has occurred at least once in each, so that it is reasonable to expect that unless further preventative means are taken, turbo-generators stand a good chance of serious damage by fire at some time during their life. Although many fires have occurred, probably most of them have happened during the generator development stage. Generators of the turbo type are of such recent production that none of them has yet reached a life which could be considered old and, therefore, the troubles which can be expected near the end of their life by fire have still to come.

9 Undoubtedly the manufacturing companies have given serious thought to the matter of the reduction of the fire hazard in turbo-generators and have employed all means practical at the present time to this end, but there is still very much to be desired. The following several means if taken together would seem to minimize the chances of a serious fire:

a If a suitable material could be found a non-combustible outer covering could be placed over the insulation on the stator end connections. This would greatly delay the spread of fire and even if no other protective means were taken, would undoubtedly prevent much serious damage. Where fire extinguishers were used the covering would at least hold back the fire until they could be brought into play. At present no material suitable for such a covering appears to be available.

b If a non-combustible outer covering should be put on, its advantages would be partially lost in time unless the cooling air were freed of the dirt and oily vapor liable to be in it. This could be done by filtering, as has already been advocated several times.

c Means could be provided for cutting off the air supply in case of fire in generators by placing dampers in the inlet ducts designed so as to be normally held open by fusible links. The links could be placed so that they would be quickly fused by the heat and allow the dampers to close automatically. By reducing the oxygen supply to that entering by leakage the action of the fire would be slow.

d Arrangements could be provided for the quick introduction of carbon dioxide gas into the machines. The carbon dioxide could be kept in liquid form and piped through valves, expansion tanks, etc., to the generators. The valves could be arranged to be opened by the closing of the air inlet dampers so that the gas would be automatically introduced into the generators. This gas would be very effective in extinguishing fires inside the machines after the air supply had been cut off.

10 The employment of some efficient method of reducing the fire hazard in generators of the turbo type either along the lines

mentioned or in some other way is important. The value of these generators is great and the damage by fire may amount to a considerable proportion of the first cost. It is probable that the damage is more liable to occur towards the end of the life of the generators, but even then the loss may be large, both directly and indirectly. The large central stations have reserve units so that the increased damage due to fire in one of their generators would probably not affect the continuity of service, but the increased time necessary for repairs may be long and during this time the reserve capacity will be weakened. In the case of industrial plants the longer time needed for repairs might be serious. Many manufacturing concerns who generate their own current depend on only one unit and, therefore, their whole production, or a large part of it, would be affected.

THE CENTRIFUGAL BLOWER FOR HIGH PRESSURES

By Henry F. Schmidt, Published in The Journal for November 1912

ABSTRACT OF PAPER

In this paper the author gives the essential elements of blower design in convenient form for reference. An equation is derived representing the work done in a centrifugal blower and the differences between this type and a piston compressor are discussed. There is a discussion of efficiencies and characteristics of impellers in series, of guide-vane and volute types of blowers and variations of pressure in the case of guide-vane blowers as the volume of discharge increases. The theory of diffusion vanes is examined in detail, and an equation for the loss of kinetic energy derived.

Design of volute blowers is taken up and discussion of the influence of the relation between efficiency curve and discharge rate, as well as between the blower characteristic and efficiency curve in this type of blower; an equation for the velocity conversion efficiency is derived, and the constancy of pressure in a blower having a free vorte mathematically demonstrated. The Westinghouse design of volute blower is used for illustration.

The latter part of the article is devoted to methods of testing and calculation of centrifugal blowers.

DISCUSSION

W. H. Carrier objected to the author's statement that the loss in radial flow is overcome by the use of the volute casing. This thing was tried out some years ago in pumps, but found by means of tests to be of no advantage. As to the loss at the inlets, everything depends on the relative length of the blades, as the author admitted, a fact which the designers of centrifugal machinery have taken advantage of by proportioning the inlets of their vanes properly. The speaker made tests some years ago to determine the proper size of inlets for a given quantity of air

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

and speed. There is a relationship which can be proved both mathematically and experimentally, between air per minute, speed and diameter of the inlet, the diameter of the inlet being determined by the other two. A fan can be very inefficient if the inlet be too large or too small for a given speed and a given quantity of air, and there actually are many such inefficient fans on the market.

C. J. H. Woodbury said that the drawings of the compression of air do not represent what takes place in the blower. They represent the streams of issuing air as though they were streams of water running through a river, whereas it is merely a difference in density which might be represented by lines nearer together. The speaker also called attention to another form of centrifugal blower, in which augmentation of radial efficiency of the pressure is obtained by making the vanes of variable thickness, so as to make the spaces between the blades at the periphery less than at the sides towards the center, or, in other words, applying the principle of a hose nozzle to a blower.

R. H. Rice, in a written discussion, made the following objections to some of Mr. Schmidt's statements as the result of an extended experience in the design and construction of such apparatus running into the installation and operation of many hundreds of sets, as well as an immense amount of experimental and research work conducted under his direction.

In Par. 8 Mr. Schmidt reaches the conclusion that the maximum efficiency of a centrifugal compressor, without conversion of the final velocity of air into pressure, can be only 50 per cent as a maximum, neglecting all losses. This conclusion is correct. It is also correct, as he states in this same paragraph, that there are three means of effecting this conversion. But in Par. 9 he admits that the first method is the most efficient at the designed capacity, while incorrectly stating that this method is inefficient at large and small discharge rates.

In Par. 11 he states that diffusion tubes attached to the discharge are inefficient, but he incorrectly gives the reason for this inefficiency. The diffusion tube is simply the down-stream half of a venturi meter, and we are all familiar with the fact that venturi meters are efficient for measuring both compressible and incompressible fluids. If this portion of the meter were ineffi-

cient as a converter of velocity into pressure, the meter itself would be inefficient. The reason for the inefficiency of a diffusion tube attached to the discharge is the long and tortuous path which the air is required to pass over after leaving the impeller before reaching the diffusion tube; and the fact that this air moves at a very high velocity in so doing.

In Pars. 12 and 13, Mr. Schmidt shows that the efficiency of the centrifugal blower remains the same with a reduced number of revolutions provided the volume is reduced, but does not give the law, which is, that quantity divided by number of revolutions, $\frac{Q}{N}$, must be constant.

In Par. 15, it is stated that the characteristics of a guide vane blower are shown by Fig. 6, and that the pressure fluctuates in such a machine throughout the range of volume. This statement is quite incorrect. The only fluctuations of pressure met with in a guide vane blower are those due to a rising pressure characteristic at the early part of the volume pressure curve; and in a properly designed volute blower the pressure volume curve has the same characteristics and the same fluctuations are met with. In the guide vane compressor when properly designed there are no pressure fluctuations for loads greater than 1/3 or ½ of the rated volume as can be seen by inspection of any of several hundreds of these machines which the writer has designed and which are now in operation all over the country. Furthermore the relation of the pressure and efficiency curves, shown in Fig. 6, are those of an improper design. No designer experienced in the art of guide vane blower construction would find it necessary to place the peak of the efficiency curve at a point where the pressure has dropped to less than half the maximum. Consequently, the conclusions drawn from inspection of Fig. 6 are incorrect both as regards the character of the pressure curve, and as regards the relation of the pressure curve to the efficiency curve.

In general a volute blower will have larger dimensions than a guide vane blower to effect the same result; and the frictional and eddy losses in a volute blower will be greater than those in a guide vane type, due to the imperfect guidance of the air and somewhat greater surface exposed to friction.

In Par. 18, Mr. Schmidt states that no pressure is created by the diffuser type, or, by implication, by the discharge vane machine, when no volume is being delivered. This statement is,

however, not correct. An appreciable increase in pressure over that due to the centrifugal effect is met with in properly designed discharge vane machines.

In Par. 23, Mr. Schmidt states that the volute blower shown in Fig. 5 has an entirely different characteristic, the theoretical characteristic being, namely, a perfectly straight, or constant pressure, line for any delivery. This characteristic is not peculiar to volute blowers and referring to Par. 24, it is shown in Fig. 22 that the characteristics of the efficiency curve are the same in both types of machines, with the exception that the peak of the efficiency curve in the volute machine, shown by Mr. Schmidt, is much lower than the peak of the efficiency curve in a properly designed discharge vane machine for the reasons before set forth.

The real reason for the flat pressure curve of Mr. Schmidt (Figs. 7 and 10) is that he is not getting the proper conversion of velocity into pressure as the load comes on; therefore, he is not realizing from a given diameter of impeller the full amount of pressure possible with good design. In this connection Fig. 23 shows a machine with good velocity-pressure conversion (in full line), and the dotted lines show the result to be obtained if the velocity was not fully converted into pressure in the volute. This figure refers to a machine with volute casing, no discharge vanes, and so-called free vortex.

Pars. 30-34 are devoted to an attempt to show that a radial inlet taking the air without shock is not inefficient. The obvious answer to this contention is Par. 35 in which it is shown that in an attempt to overcome the losses of such impellers, the inlet is made in the form of a volute and forced vortex. No doubt such a construction can be made to increase the efficiency, or decrease the losses of impellers with radial inlets, but it is impossible that this construction should give as satisfactory results as the one in which the edges of the impellers are formed to take the air without shock and without whirling, and extensive experiments show that it does not.

In Par. 37 Mr. Schmidt states that there is only one good construction for impellers. Engineers who are accustomed to deal with the problems of actual design will realize the impossibility of fixing on any one construction as the best for all circumstances. Furthermore, Mr. Schmidt makes it appear to be impossible to construct successfully a multi-stage machine since he states that the disks should not be provided with any hub or hole

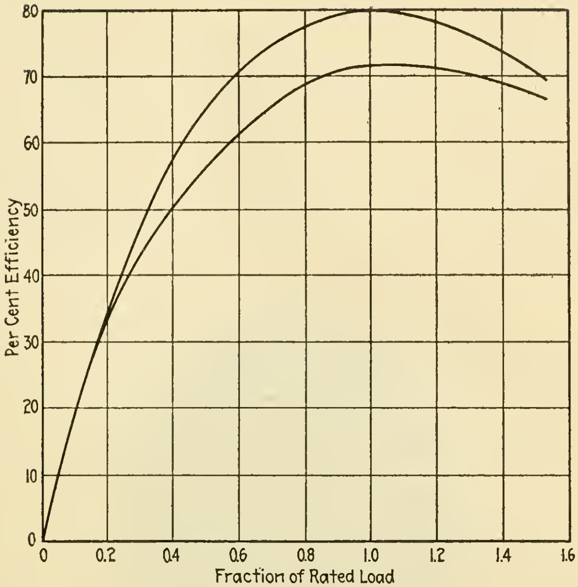

FIG. 22 EFFICIENCY CURVES OF VOLUTE AND DISCHARGE VANE MACHINES

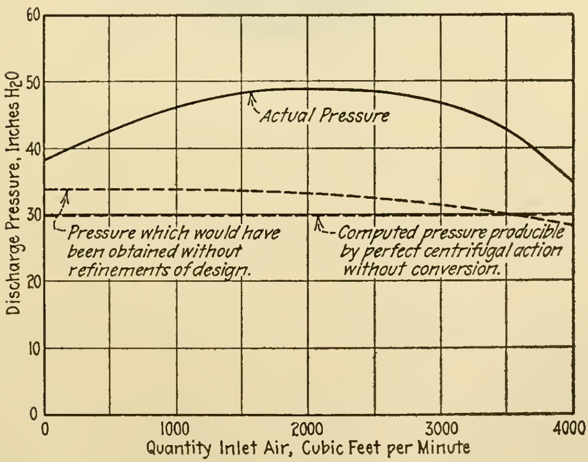

FIG. 23 PRESSURE CHARACTERISTIC OF MACHINE WITH VOLUTE CASING, FREE VORTEX AND NO DISCHARGE VANES

for the shaft. The fact that hundreds of machines are operating with this form of construction apparently has no weight with Mr. Schmidt. This question is safely left to the judgment of engineers as to the possibilities of the situation.

In Par. 36 the author states that his straight radial blades are the only ones which can be used except at the lowest speeds. The impeller illustrated in Fig. 24, which has the blades so arranged that all the metal is disposed along radial lines (while at the same time the air is met without shock), shows that there are

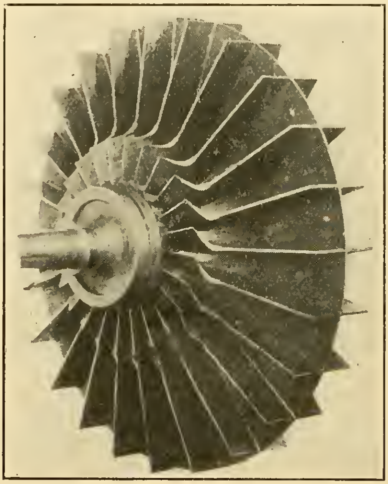

Fig. 24 Impeller with Metal Arranged along Radial Lines

constructions not mentioned by Mr. Schmidt, which are adequate for all situations.

It will be noted in the impeller shown that all the vanes extend to and derive support from the hub, thus gaining strength not possessed by Mr. Schmidt's construction.

S. A. Moss (written). Mr. Schmidt assumes that what he calls volute blowers are inherently more efficient at light loads than what he calls discharge vane blowers. However, the data which he gives in Fig. 10 show quite the contrary, as Mr. Crissey has independently noticed. The blower which he marks 40,000 cu. ft. has a curve with rising pressure characteristic and this gives higher efficiency than the curve which he marks 30,000 cu. ft., which has no pressure rise above no load. I have replotted Fig.

10 as Fig. 25, using fractions of best load as abscissae. The best load for the 30,000-cu. ft. curve is at 25,000 ft. and all of the abscissae of this curve have been divided by this number. The peak of the 40,000-ft. curve is not shown and has been assumed 60,000 and all of its abscissae have been divided by this number. This brings the two curves to a common basis. As will be seen the machine with the rising pressure characteristic has a higher efficiency at the peak and rises more rapidly at light loads. Mr. Schmidt states in Par. 24 that curves such as Figs. 6 and 7, if plotted to scale, would show decreased light load efficiency for guide vanes. This is not borne out by the facts he presents however.

A blower of the type discussed, with a rising pressure characteristic, gives such rise of pressure purely by better velocity conversion with the same shaft power input, and hence necessarily better efficiency than a blower which gives no pressure rise above the no-load value. As Mr. Rice has mentioned this rise can be secured by discharge vanes or a good volute.

Mr. Schmidt introduces in Pars. 25 and 26 a discussion of the mathematician's free vortex. The presumption is that he uses this in his blowers as well as the volute casing of Fig. 5. He attempts to show that a blower with a free vortex would give a flat characteristic curve with considerable velocity conversion at all loads. At very light loads, however, there is enormous friction loss in a free vortex since the angle between the path of the fluid and a tangent is very small. At a very small load close to zero, a particle of fluid must travel around the circumference many times before it gets out. At slightly larger loads the particle travels around fewer times. As the load increases the path of the particle becomes shorter and shorter, and the friction and eddy losses become much smaller percentages. Hence one would expect a volute with a free vortex to give a curve such as was actually obtained in Fig. 23, presented by Mr. Rice, with increased conversion as we go away from zero load.

Hence a free vortex cannot give good conversion at very light loads on account of the large proportion of friction and eddy losses. If now the pressure does not rise at full load, it follows that undue friction losses exist there also, which can however be removed by efficient design. Hence an actual blower which gives a flat characteristic does not do it because of inherent design, but

because the upper portions of pressure and efficiency curves are lost.

Mr. Schmidt gives a discussion of the action of a diffuser tube in connection with Fig. 8, in which he rightly states that for each velocity at the point of minimum section there is a pressure at the end of the tube which gives equilibrium. Mr. Schmidt's own explanation shows that there is no fluctuation of pressure in a blower using an equivalent of a diffuser tube. As the vol-

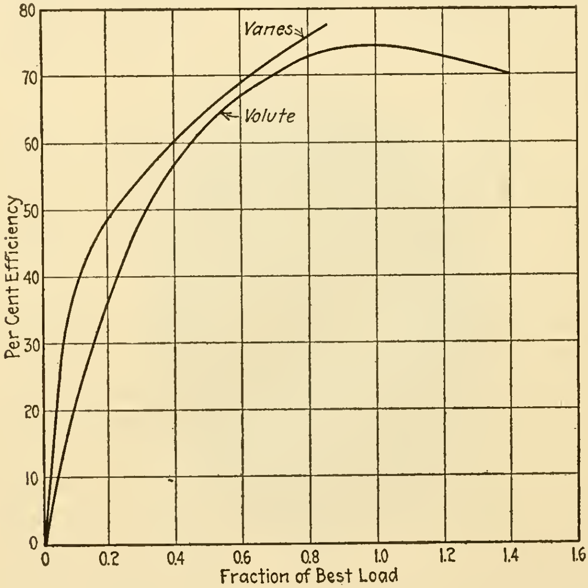

Fig. 25 Characteristics of Two Blowers under Different Efficiency Curves

ume passing through the blower changes so as to change the velocity at the beginning of the tube, the blower itself produces a pressure corresponding to the new conditions. In other words, for every load or volume passing through the blower there is a certain pressure which the blower itself produces due to the particular velocity in the conversion tube and to all the other occurrences when this volume is passing. That is to say, there is a perfectly definite pressure volume curve such as shown in upper part of Mr. Schmidt's Fig. 10 and for any given volume which is being used the pressure produced by the blower is the pressure occurring at this volume on the pressure volume curve. This is the pressure which exists in the pipe line to which the blower

is connected. If the load and hence the velocity is changing from one value to another, the pressure gradually changes to the new value without any fluctuation or pulsation. Mr. Schmidt supposes the case of a high velocity jet discharged into a receiver through a diffuser or venturi tube. It is, of course, to be understood that there is an orifice leading from the receiver so that the air entering can also leave and that there is no other air supply to the receiver. If now the velocity at the entrance to the venturi tube be gradually decreased there will, as Mr. Schmidt supposes, be a new pressure of equilibrium and the pressure in the receiver will gradually and calmly vary until it is again in equilibrium with the velocity. The explanation which Mr. Schmidt gives shows that there will not be any pulsation. The pressure in the receiver is fixed only by the velocity at the entrance to the venturi tube and is always the pressure in equilibrium with this velocity. There are thousands of venturi meters in use which illustrate the same point. These make use of a diffuser tube such as Mr. Schmidt mentions and discharge into a pipe system beyond corresponding to a receiver. If now the flow through the system is reduced, the velocity at the throat of the venturi meter at entrance to the venturi tube decreases. This decreases the pressure rise along the venturi tube, but in a slow and gradual manner and a new position of equilibrium is reached without any fluctuation or pulsation whatever. Evidently the same action takes place in any type of diffuser or volute or free vortex which accomplishes conversion of velocity into pressure.

The mathematical portion of Mr. Schmidt's paper can be given in the following simplified way. In the first place we note that the theoretical work for adiabatic compression of 1 lb. of air from absolute pressure P_2 to absolute pressure P_1 in ft-lb. is

$$\frac{\gamma}{\gamma-1}\,\frac{144\,P_o}{\rho_o T_o}\,T_2 K$$

where

γ = ratio of specific heats

$K = \left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}} - 1$

T_2 = initial absolute temperature

P_o, T_o, ρ_o = absolute pressure in lb. per sq. in., absolute fahr. temperature; and density in lb. per cu. ft., at any standard condition

Now consider a pound of air which enters a rotating wheel at the center and passes outward to the periphery always with negligible velocity. Work is done against the forces which keep the relative radial velocity negligible and this work appears as work of adiabatic compression of the air. The force at any radius, r feet, against which the work is being done, is the so-called centrifugal force, which for a pound of air is well known to be

$$\frac{r}{g}\left(\frac{2\pi N}{60}\right)^2$$

This force varies uniformly along the radius so that the average value is one-half the maximum value at the outside radius r_1. The work done is this average value multiplied by the total distance which is the maximum radius, r_1, which is therefore

$$\frac{1}{2g}\left(\frac{2\pi N r_1}{60}\right)^2 \text{ or } \frac{\mu_1^2}{2g}$$

if μ_1 is the peripheral velocity of the wheel in ft. per sec. This is the work done in ft-lb. in passing a pound of air from the center of a rotating wheel to the pressure at the outside of the wheel, the relative velocity along the wheel always being negligible. This is necessarily equal to the adiabatic work of compression and delivery to the pressure existing at the periphery of the wheel given above. This covers all of the points given in Mr. Schmidt's Pars. 6 and 7 leading to his equation [2]. It is to be noted that this covers only the case where fluid is taken on the wheel at the mathematical center and where the relative radial velocity along the wheel is always negligible. Extension to the actual case where the fluid is taken on the wheel at a considerable radius and where there is an absolute tangential velocity of the fluid at the point where it is taken on the wheel as in Mr. Schmidt's Fig. 15 and where the relative velocity along the wheel and particularly at the circumference is not negligible but has an appreciable value, are matters which must be analyzed in addition and which Mr. Schmidt wholly omits. Mr. Schmidt's analyses of the actual occurrences in a centrifugal blower are therefore only approximate.

Mr. Schmidt's method of calculation of the theoretical horsepower of a blower given in Pars. 45 and 46 can be simplified by computing independently the quantity discharged from the ori-

fice in cu. ft. of air per min. if reduced to absolute pressure and temperature existing at the blower inlet. This avoids altogether direct computation of the velocity or volume at orifice end conditions. Using the analysis which Mr. Schmidt gives in Par. 46, the volume discharged from the orifice with total pressure P_1 absolute temperature T_1 expressed in cu. ft. per min. if reduced to actual absolute temperature T_2 at inlet and pressure P_2 at orifice end and inlet is

$$Q = 6540 \frac{A T_2}{\sqrt{T_1}} \sqrt{(K+1)K}$$

Here 6540 is $60 \sqrt{2gJC}$, and A is the orifice area in sq. ft. multiplied by the velocity coefficient. K is the same as above if discharge and orifice pressure are both P_1. The theoretical horsepower for compression and delivery per minute of a body of air occupying a volume of one cu. ft. at inlet conditions is

$$H = \frac{144 P_2 K}{33{,}000} \frac{\gamma}{\gamma - 1}$$

Here P_2 is absolute inlet pressure in lb. per sq. in. The theoretical horsepower for the blower is then HQ. This is an expression equivalent to Mr. Schmidt's equation [10], and I believe will be found easier to handle. The expression for Q can also be simplified by means of a very exact approximation originated by Bossinesq and discussed in a paper on the general subject of discharge of air in American Machinist.[1]

C. P. Crissey (written) expressed his belief that the author has compared the Westinghouse volute blower with turbo-blowers of inferior design, which makes the conclusions inadmissible. Neither pulsations over the range of volume indicated in Fig. 6, nor sharp peaked efficiency curves with rapid drops on either side of the peak are inherently characteristic of the turbo-blower, and indicate simply poor design.

The author gives some curves in Fig. 10 but supplies insufficient information regarding them. Even the speed of the turbo-blower is lacking and we are not informed concerning such points as the clearance between impeller and diffusion vanes, whether the vanes are straight and radial, straight without being radial, or curved.

Sept. 20, 27, 1906.

The comparison shown in Fig. 10 might well be plotted with abscissae taken as fractions of the rated capacity. It will be seen that the volute blower reaches its maximum efficiency before full capacity, while the turbo-blower efficiency is still rising beyond one and one-quarter load. This latter curve shows again that the design of the turbo-blower is not correct, because it is perfectly feasible to have the efficiency curve of a turbo-blower reach its maximum at full load or at less than full load quantity as desired. It will be noted that the efficiency curve of the volute blower falls off about 8 per cent from the maximum at half and at one and one-quarter capacity. The best turbo-blowers for such low pressures and large capacities will show less reduction in efficiency for corresponding points, when the efficiency is a maximum near full load, and the maximum efficiency will be higher than that of the volute type; therefore the efficiency throughout the usual working range is better.

Every builder of turbo-pumps, turbo-blowers and turbo-compressors would like to omit diffusion vanes because they add to the expense of production, but experience has shown that they are advantageous. Their use led to the introduction of multi-stage high-pressure centrifugal pumps, and experience with turbo-blowers and compressors confirms their value. After careful experiments, Professor Rateau advised his liensees to construct machines without diffusion vanes, but the results were not as expected, and these builders are now in general using diffusion vanes; even careful experimental researches are not always conclusive.

Par. 36 states that straight radial blades are the only ones which can be used except at the very lowest speeds. The majority of turbo-blowers and compressors in service throughout the world do not, however, have such blades. Par. 37 is also misleading, as the great majority of turbo-blower and compressor manufacturers use with satisfaction impellers of built-up construction, while a number of those who began by using solid impellers have abandoned them. Double flow impellers are very good, but single flow are equally satisfactory and are widely used for multi-stage work upon the continent of Europe because of the complications in design and increase in length, weight and cost resulting from connecting a number of double flow impellers in series. The statement that an impeller disk should not have a hub or hole for the shaft almost refutes itself, as thousands of rotating

disks with holes for shafts are today operating with satisfaction in steam turbines, blowers and compressors.

The writer prefers the European method of test to that used by Mr. Schmidt. It is usual to rate and guarantee these machines in terms of atmospheric temperature and pressure; therefore the use of a nozzle in the discharge necessitates numerous and large corrections all tending to introduce errors, to say nothing of radiation effects which take place at high air temperatures. Experience has shown it to be more accurate as well as simpler to use a nozzle in the suction pipe. The formula for the weight of air entering the compressor is then

$$G=2.056\ FP_2C\sqrt{\frac{B^{0.286}}{T}(B^{0.286}-1)}$$

in which

G = weight of air in lb. per second.
F = area of nozzle in sq. in.
P_2 = absolute pressure within suction chamber in lb. per sq. in.
C = nozzle coefficient.
T = absolute temperature of atmosphere in deg. fahr.
P_1 = absolute pressure of atmosphere in lb. per sq. in.
$B = \frac{P_1}{P_2}$

Attention is called to two minor errors. In Par. 13 the work done per lb. of air is said to vary as the number of revolutions. This should of course read as the square of the number of revolutions. The speed for the volute blower of Fig. 10 is given as 3600 r.p.m. on the volume pressure curve, and 3000 r.p.m. on the efficiency curve. Doubtless both curves are for one speed or the other. The symbol P_1 has been used in a number of places to represent the total head (static plus velocity), but in the appendix it is stated to represent only the static head. It is correct in itself, but leaves the significance of the symbol P_2 doubtful.

C. G. de Laval. The notes by the author about centrifugal blowers are interesting and make an attempt to supply the knowledge relating to turbo compressors and blowers of which not much is known up to the present. However, considerable valuable data that may change the theory presented by the author can be found in the able articles relating to this in Dingler's polytechnisches Journal, April 1912, and as early as October 1910,

in the Zeitschrift des Vereines deutscher Ingenieure, Zeitschrift für das Gesamte Turbinenwesen of September 1912, and Theorie and Konstruktion der Turbo-Kompressoren von Ostertag.

The steam turbine is responsible for the introduction of the turbo-compressors and followed rather behind the turbo-pump. The design of modern turbo-blowers follows that of the turbo-pumps and not that of the ordinary volute pumps. Experiments by Rateau and Parsons, Jaeger, Pokorny & Wittekind, and others, distinctly point to the rational design of diffusers as solving this problem.

Parsons, however, in his early machines proceeded on a theory of axial compression, but as soon as he found out the excellent results of Professor Armengaud and others, he produced similar blowers. Without going into the merits and demerits of axial and radial machines it can be said that all modern designs show a radial development for turbo-compressors as entirely opposed to the development of steam turbines, which are almost entirely designed on the axial system.

The statement that the transforming velocity into pressure by three ways with the stress laid upon the method of the use of a volute of proper design is in theory not correct. Only one method used today for transforming this velocity into pressure seems satisfactory, and that is the use of a diffusor or what may be termed a long nozzle, which we all know is the best for liquids. A diffusor is only a series of nozzles of sufficient number to take care of the volume.

There appears to be nothing different in a turbo-compressor than in a turbo-pump except as to the reduction of volume and its increase in temperature; the only difference is the unit of the gas or air pumped which is much smaller than water. The theory applying to a centrifugal or turbine pump can be fully applied here, and the pressure multiplied with the volume being constant is enough to calculate all data in connection with these machines. The relation between pressure and velocity is $p = \frac{v^2 S}{2g}$, in which $v =$ velocity and $p =$ pressure, $S =$ specific gravity and $g =$ acceleration. As air weighs only a fraction of water its ratio to water means that it will take that much greater peripheral velocity to sustain the same head of water. The principal equation to consider in a turbo-compressor is $pv^n =$ con-

stant where $n = 1$ or $n = k$, the former for isothermal and the latter for adiabatic compression.

Without going into the application of these formulæ we may say that the most rational theory applied to impellers is that derived from turbine pumps, with the addition of a shockless entrance and exit to impellers, from which the theoretical head can be calculated for each impeller.

The different purposes for which turbo-blowers or turbo-machines are used require more or less steep characteristics, the same as in turbine pumps. While the characteristics of a pump are practically independent of any change in temperature the turbo-blower is influenced by it to some extent. Characteristics herewith are given for different services and taken from diffusion vane machines (Fig. 26). A constant discharge air pressure for constant speed is no reason for a flat characteristic; on the other hand a steep characteristic curve is desirable when different pressures are to be attained at constant speed. The designer of a diffusion vane machine can obtain any type of characteristic he desires, and a flat characteristic curve is obtained by changing the vane angle. The diffusor or volute has very little influence on the slope of the curve. The efficiency curve should always be as flat as possible. A volute type of blower or compressor is not one that can be adopted for medium and high pressures on account of the difficulty in combining a number of volutes so as to form a unit.

As to the idea advanced as to guide or diffusion vanes and guide vanes, it has been shown by extended experiments that the maximum efficiency has been obtained by diffusors of various shapes and that such vanes do not take away any mechanical efficiency or affect the thermic efficiency on account of friction and heat.

Referring to the method of measurement of capacity which is by the discharge, the guarantees are always based on a certain displacement of air at atmospheric pressure, and it is therefore best to determine the capacity by an orifice attached to the inlet pipes. If the air is measured at the discharge, the kinetic output of energy and radiation losses must be considered and allowance made. The measurement at the entrance is simpler and in the calculation of the results much time can be saved which often extends over days in order to obtain sufficient points for the characteristic.

With the orifice in the air entrance, the correction for temperature or barometer as well as the doubtful determination of the kinetic energy in the output air is dispensed with.

As regards the determination of the adiabatic efficiency from the temperature it may be said that this is purely theoretical and that in practice the radiation losses and the heat caused by bearing friction do not appear in the heat absorbed by the air,

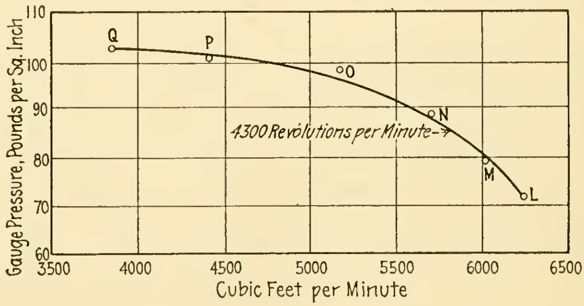

FIG. 26-A CHARACTERISTIC CURVE FOR TURBO COMPRESSOR

the temperature of which must therefore be lower than the theoretical. The formula for efficiency

$$E^1 = \frac{T_1 - T_2}{T_1' - T_2}$$

where

T_1 = theoretical final temperature of the air calculated from the adiabatic relation between pressure and temperature

T_2 = initial temperature of the inlet air

T''_1 = final observed temperature

is therefore imperfect and to the final temperature must be added the above mentioned losses and a third loss caused by the kinetic energy of the air leaving the compressor. This energy converted into pressure would cause an additional rise in temperature.

If we designate the temperature equivalents of the various losses as follows

T_f = bearing friction

T_r = radiation

T_k = kinetic energy

the above formula then becomes

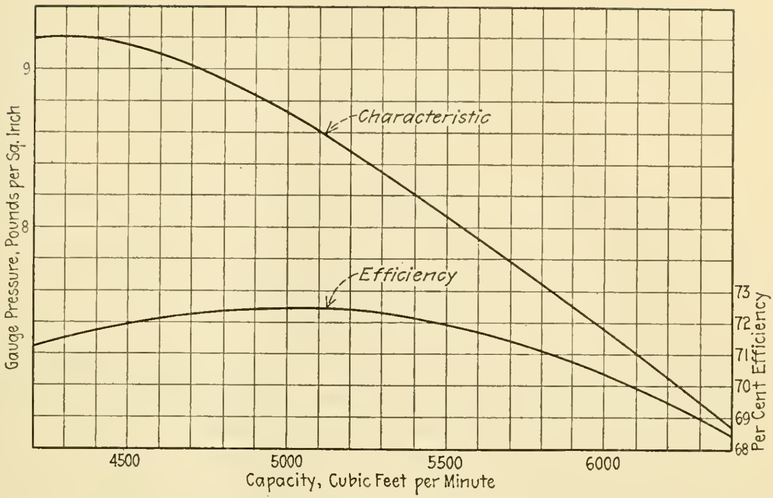

FIG. 26-B CHARACTERISTIC CURVE FOR TURBO BLOWER

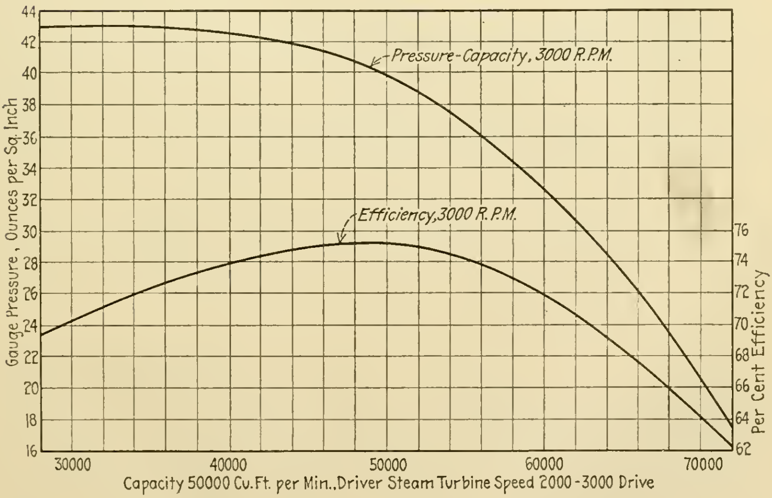

FIG. 26-C CHARACTERISTIC CURVE FOR TURBO BLOWER

$$E' = \frac{T_1 - T_2}{T' + T_f + T_r + T_k - T_2}$$

In the article under consideration the following formula is given:

$$E' = \frac{\frac{\gamma}{\gamma-1} RT_2 \left[\left(\frac{P'}{P_2}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}{\frac{\gamma}{\gamma-1} RT_2 \left[\left(\frac{P'}{P_2}\right)^{1-\beta} - 1\right]} = \frac{T_1 - T_2}{T^1 - T_2} \qquad [21$$

which, however, is nothing but the fundamental equation

$$E = \frac{\text{air horsepower}}{\text{power input}}$$

Formula [21] can therefore be used only when the losses are known and serves at best to check the air horsepower or the efficiency in relation to the indicated horsepower.

The laws governing turbo-blowers or compressors are well understood by engineers and this new style of machine which has been brought out will be a factor in the compressor field which is now occupied by displacement machines, the efficiency of turbo-blowers being equivalent to piston blowers working under same conditions. This fact has been rather difficult to prove on account of the different methods used by measuring efficiency of both types.

The judging of a piston machine by figuring efficiency from diagrams obtaining the mechanical efficiency accurately, is of course not right as it includes only the external mechanical losses, and does not include losses due to heating and incomplete filling and expansion of air taken into the valves, all of which will reduce the volumetric efficiency. A piston machine to be compared with a turbo-machine should have the quantity, weight and pressure measured after it leaves the machine and the amount of power used for compressing this quantity without increase in temperature.

Albert E. Guy. Two points of main importance are to be considered in the construction of an otherwise well designed centrifugal air compressor or pump: One is that the direction and the velocity of the fluid at the point of contact with the first element of the vanes, or vane inlet, are fundamental factors in the calculation and delineation of the shape of the vanes. Therefore, when anything occurs which deviates the direction

and changes the velocity of the fluid at the vane inlet, the performance of the machine will be different from, and invariably not so good as was intended. The other is that, as the fluid leaves the impeller nothing can add to the energy it possesses, and everything it contacts with, be it diffuser passage, diffuser vanes, free whirlpool, or easy return bend, will cause a reduction of that energy.

The energy producer is the impeller; it must be designed to meet the conditions imposed by the customer and which may be specified in various ways. No contact for either a centrifugal pump or a blower should be let which does not include a set of guaranteed curves, one of which, named the characteristic or performance curve, represents the variation of head corresponding to the variation of the volume delivered, the speed remaining constant throughout the whole range. The second curve represents the efficiency, that is the ratio between the useful work and the total input work. The third curve represents the brake horsepower. The second and third curves are so placed relatively to the first that both the efficiency and brake horsepower corresponding to one head-volume point on the performance curve can be measured on the ordinate of that point.

The specifications imposed may require that three given sets of conditions be met at the same speed, for instance. The performance curve must therefore enclose three points and yet be a fair curve. It may happen that two of the points cannot be exactly placed on the curve, but once the curve is established to the satisfaction of both the prospective customer and the designer, the impeller is entirely determined. The beginning of the curve at no delivery determines the diameter of the impeller for the stated constant speed, of course, and the post normal part of the curve, that is, the part following the normal point or point of maximum efficiency, determines the areas of sections throughout the impeller. The inlet and outlet angles are fixed by the conditions at the normal point. The shape of the vanes depends on the theory followed.

The apparatus once installed should be tested and the results of the tests embodied in the form of curves. Such curves should then approximate very closely those embodied in the contract. It is quite evident that a wrongly designed impeller cannot produce test curves matching the proposed curves.

Some engineers and writers have claimed that as long as the impeller vane has the proper angles at the inlet and outlet respectively, its shape between these points is of no special importance. This is absolutely wrong. The writer in more than 20 years of practice has found it absolutely necessary, in order to produce a high grade machine capable of meeting predetermined conditions of operation, to calculate the shape of the vanes from the beginning to the end with the greatest degree of accuracy. All the formulae in use today for calculating the impeller can be easily shown to originate from Professor Combes' formula. The three formulae given in Mr. Carl DeLaval's book on Centrifugal Pumps, for instance, are clearly derived from the Fink formula published in the German handbook "Die Hütte," and Fink's formula is clearly derived from Combes'. These formulae have been published in various forms by different authors, but like the thermodynamic formulae at the time of Clausius, they only consider the initial and end conditions, and disregard the work produced between them. However a skillful designer may, by using the Combes formula, produce impellers which will cover quite a range of conditions.

The author's statement, in connection with Figs. 6 and 7, in the writer's opinion are contrary to facts and his theory is obviously erroneous. The compressor described is the same as that which formed the subject of the discussion by R. N. Ehrhart of a paper on turbo-compressors[1] and is simply an enlarged fan of the type first described and made by Professor Rateau some years ago. The high speed at which the impeller runs requires that the vanes be made radial and carved out of the solid, hence shock is unavoidable at the vane inlet, the fluid path throughout the impeller is uncertain and no theory can apply to this sort of design unless a special coefficient of correction be introduced after careful deductions from a large number of accurately made tests of apparatus of various sizes. There is no evidence produced by the authors that such tests have been conducted.

The paper would lead to the belief that the shape of the casing has a great influence on the characteristic curve. This is on par with several patent specifications quoted by Poillon in his book on pumping machinery, in which some French inventors about 30 years ago asserted that the impeller had, of course,

[1] Trans. Am. Soc. M. E., vol. 33, p. 396.

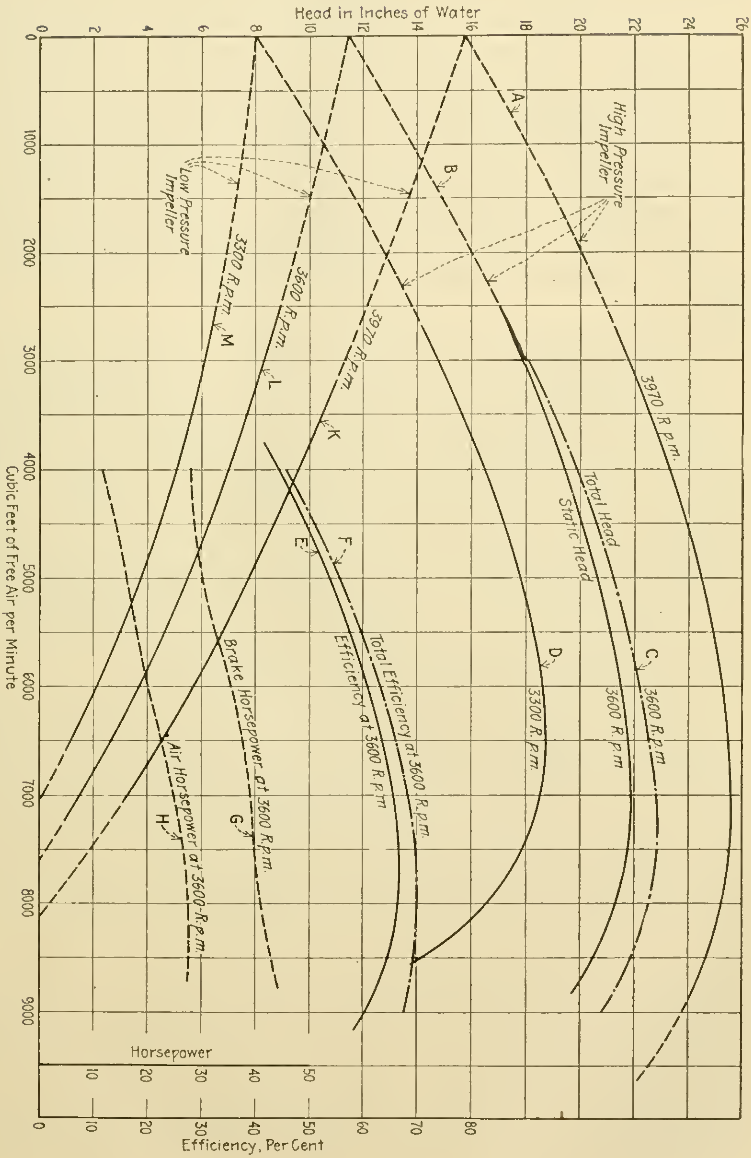

Fig. 27 Characteristics of the Two Impellers Tested

but unfortunately, to be a part of the pump, but that the predominant factor was the casing and its volute, made sometimes with and sometimes without diffuser passage.

A few years ago the writer undertook a series of experiments to show that the form of the vanes determined absolutely the characteristic curve. Some of these experiments were described in Power[1] and the test curves are reproduced in Figs. 27 and 28, and were found to match those established before the apparatus was constructed. Two fans were made to suit the same casing which was of the plain volute box form. The fans had exactly the same outside and inside diameters, viz., 18 in. and 12 in. respectively, and the width measured axially was 6 5/8 in. for both.

Thus, the runners being of the enclosed type, there was nothing outwardly to distinguish them one from the other, and as a matter of fact they differed only in the form of the blading, as shown in Fig. 28. These fans were run at 3600 r.p.m. and at that speed, for which they were designed, one gave 7000 cu. ft. of free air per minute at a pressure of 22 in. of water gage; the other, at the same speed gave 5250 cu. ft. of free air per minute at a pressure of 5 in. of water gage. At corresponding speeds it is seen that the characteristic curves of both fans began at precisely the same point, and thenceforth diverged as would of course be indicated by the proper theory.

A correctly designed impeller would work well in a casing of the box form, that is without diffuser passages, diffuser vanes or volute, provided, however, that the discharge from the periphery of the impeller is not interfered with or choked. To some extent the plain centrifugal pump of the multi-stage type is an example of this in which smooth passages are provided, but without a volute connecting one stage to the other. The efficiency of this pump is just as high as that of the double suction volute centrifugal pump.

The author gives no detail drawings of the impeller and casing and the matter as presented is vague, yet the statements of the paper are such as to amount to a claim for an important discovery, viz., that the form of casing virtually controls the performance curve of the impeller. The questions of centrifugal air compressors and pumps are of prime importance and should

[1]Horsepower of a Fan Blower, Power, June 13, 1911, p. 904.

be presented before a body like this society in a manner to permit the interested members to deal with complete fundamental data and facts which can be easily verified.

The Author. Mr. Carrier remarked about the relation of the inlet to the outlet diameter of the impeller and suggested that the efficiency of the impeller depended upon the ratio of these diameters. The author has, however, proved by experiment that this relation does not affect the efficiency of the blower materially if all other proportions of the blower are correct for the particular impeller employed.

Mr. Woodbury objects to the presentation of the author's illus-

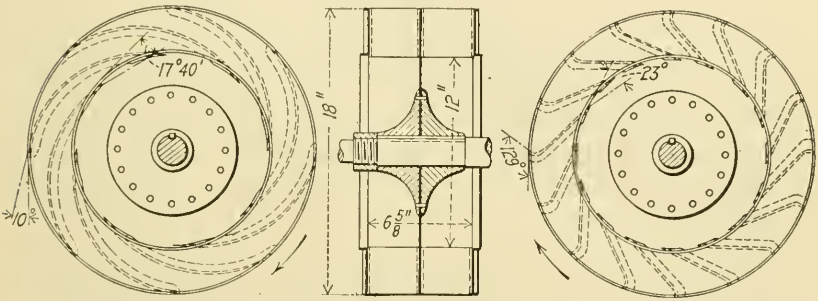

Fig. 28 Impellers Used Showing Curvature of Vanes

tration of the stream lines in an impeller: these are only diagrammatic. There will be, of course, a certain amount of compression on the driving face of the impeller blade.

In reply to Mr. R. H. Rice, it will be noted from the theory and mathematics presented in the writer's paper that his statements refer only to impellers having straight radial blades, with the exception that the blades may be curved at the inlet without materially affecting the theory as presented.

Referring to Par. 8, Mr. Rice acknowledges that without proper conversion of the velocity of the air leaving the tips of the blades into the form represented by pressure, the maximum efficiency neglecting all losses can be but 50 per cent.

Referring to Mr. Rice's discussion of Par. 11, in which he offers an analogy between the diffusion tube, or guide vanes, and the "down-stream half of a venturi meter, and we are all familiar with the fact that venturi meters are efficient for measuring

both compressible and incompressible fluids." Mr. Rice has here taken for illustration the use of the diffusion tube of a venturi meter which, as far as the author can see, has absolutely nothing to do with the use of the diffusion tubes or guide vanes in centrifugal blowers. The efficiency of the venturi tube as a meter is entirely independent (within very insignificant limits) of the efficiency of the diffusion tube in reconverting the velocity created, necessary for measurement, back into pressure. Moreover, manufacturers of venturi meters insist upon a distance of at least 20 diameters of the pipe from the nearest obstruction or elbow to the mouth of the meter, for the reason that the eddies set up by any obstruction cause fluctuations of and eddies in the flow to the meter. Because of these eddies, at least those which extend beyond the bowl of the meter, the efficiency of the diffusion tube is materially decreased, causing an unduly large drop in pressure through the meter, which is detrimental to its reputation because of the loss of head. The eddies forming above the throat cause inaccuracy in the measurements, which are also detrimental to its reputation. This is common experience in the use of venturi meters.

In Mr. Rice's criticism of Pars. 12 and 13 regarding the laws and variations of the revolutions and volume, the author wishes to say that in Par. 13 the law which Mr. Rice has stated in mathematical form, namely, $Q \div N = C$, is stated in the form, that the capacity varies almost directly as the number of revolutions per minute, which to the layman is probably more comprehensible than when expressed in mathematical form. Through an oversight in proofreading, it is stated that the work in foot-pounds per pound of air varies directly as the square of the tip speed, or if the diameter of the impellers is fixed, directly as the number of revolutions per minute. This should read, directly as the square of the number of revolutions per minute.

Further in regard to the venturi meter, Mr. Rice agrees that the diffusion tube of the meter does not affect its efficiency since he has omitted entirely any criticisms of Fig. 21, which is nothing more than a venturi meter without the diffusion tube for the simplicity of installation in a pipe line already in place.

In his conclusions regarding the efficiency of the diffusion tube of a venturi meter as applying to a blower, he disregards

the fact that the eddies in the air leaving the tips of the blades of the most perfectly designed impeller far exceed any that will be caused by an elbow or other obstruction to a venturi meter, and if it is found so important to take these precautions to avoid serious pressure drop in a venturi meter, the reader can draw his own conclusions as to how this would apply to a blower.

Regarding Mr. Rice's criticism of Fig. 6, while this figure is only diagrammatic, as has been stated, it is logically exact, although the pressure has fallen to half the maximum at the point of maximum efficiency. It is evident from the curves given in Mr. Rice's paper that in order to insure freedom from "up-setting," it is necessary to operate the blower on a comparatively small range below its normal rating and at less than maximum efficiency in order to avoid fluctuations of pressure in the discharge. The characteristics of the guide-vane blower, given by a curve such as Fig. 6, relate only to a blower of the guide-vane type, or more exactly to one in which the guide vanes have but a small clearance between their entrance edges and the impeller. However, if the guide vanes of a blower run with too small a clearance between the tips of the guide blades and the impeller, the noise which is created is of such an objectionably high pitch that it is impossible for operators either to run the machine or work at the furnaces, and for this reason it is the common practice of all builders of guide-vane machines to leave a clearance of anywhere from ½ to 2 in. between the tips of the impeller and the guide vanes, and this (as will be noted from the discussion of the free vortex in Par. 6) clearance though comparatively small radially; in high-speed blowers it forms a considerable proportion of the diameter and the theory shows that since most of the work done in a free vortex is performed in the portion near the impeller, a considerable part of the work of conversion of velocity into pressure is done before the air enters the guide vanes. As a consequence the characteristic of the guide-vane blower such as ordinarily manufactured shows less pressure rise from no-load to the point of maximum pressure, and less drop from the maximum pressure to the pressure at the point of maximum efficiency than is shown by Fig. 6.

In the discussion of diffusion tubes, the author referred only to the maximum point of efficiency, that is, at the point of break-

down for any given volume, and stated that it is possible for any given flow to have one point of steady pressure. This point, however, is always below the point of maximum efficiency.

Referring to Fig. 22 and to Fig. 10, in Par. 25, the word "the" before "characteristics" should have been omitted, as it was not intended that it should be understood that the 40,000-cu. ft. volume curve and efficiency curve referred to a guide-vane blower. The difference between the 40,000-cu. ft. and 30,000-cu. ft. blowers is simply a matter of the design of the impellers in relation to the design of the casing, the 40,000-cu. ft. blower having only a partial vortex conversion and a large percentage of velocity conversion in a diffusion tube attached to the outlet of the blower. This diffusion tube was quite efficient as sufficient conversion had been accomplished in the vortex to assure comparatively parallel stream lines at the entrance to the diffusion, but the low efficiency at small discharge rates is clearly shown by the increased pressure from no-load to the point of maximum pressure. The reason for the rapid falling off of pressure in this blower without increase of load was due to the fact that the casing of the machine was too small for the impeller.

Messrs. Moss and Crissey have also unfortunately misunderstood Par. 25 and assumed that the 40,000-cu. ft. blower was fitted with guide vanes.

Mr. Rice has stated in referring to Par. 7 that the reason for the flat pressure curve obtained on the free-vortex blower is due to the fact that there is not a proper conversion of velocity into pressure. The author made tests on this blower, obtaining the pressure at some 40 points, and has plotted a curve from the readings which shows that the pressure created in the free vortex at no-load was exactly equal to the pressure created by the impeller at no-load, and at full-load, that is, approximately 25,000 cu. ft. per min. The pressure created or the actual work done in foot-pounds per pound of air in the free vortex was about 20 per cent in excess of the work done in foot-pounds per pound of air in the impeller, which is contrary to Mr. Rice's statement. The actual efficiency of the free vortex from the tips of the blades to the discharge opening exceeding 90 per cent is a figure which has never been obtained in any diffusion tube no matter how carefully the stream lines are preserved at the entrance of the diffuser. These tests show comparatively uniform efficiency of

the free vortex from the range of no-load to the maximum capacity of the machine. The variation in efficiency from no-load to maximum efficiency does not exceed 15 per cent.

Referring to Fig. 23, showing the actual pressure in the guide-vane machine, the actual pressure curve is probably correct for properly designed guide-vane blowers, but the added line showing the pressure which would have been obtained without refinement of design, while probably true for a guide-vane blower having considerable clearance between the blower and the guide vanes, would have to have some absurd conditions in the guide vanes to show so flat a characteristic as the pressure above that due to "the pressure by perfect centrifugal action without conversion." In fact, there would have to be a great error in the angle of the guides or some obstruction or other means would have to be used to reduce the efficiency of the guide vanes in order to maintain this flat characteristic and avoid a change in the velocity conversion of the diffusion tubes as the load increases.

Returning to Mr. Rice's discussion of Fig. 6, he states that the inefficiency of the vortex type of blower is due to the loss of shaded area in Fig. 6 which gives the curve of Fig. 7. This statement, however, does not agree with the facts obtained on tests of vortex blowers of proper design, since, when the blower is tested, absolutely no variation occurs at any load except as hereafter noted.

In Fig. 24 Mr. Rice has shown a construction of radial bladed impeller designed to take in the air without shock without the use of the spiral inlet having blades extending into the hub, and the taking in of the air without shock is accomplished by means of what amounts to a propeller in the "eye" of the blower. Mr. Rice has failed to take into consideration the fact that in the construction of an impeller which extends radially inwards beyond the eye of the casing is necessarily inefficient at light-load and at overload. At light-load, because the entrance angle of the blades is designed for full-load, there is a tendency to take up or put in more air than is discharged. Consequently eddies are formed, due to the fact that the air taken into the inlet is in excess of that being discharged and, consequently by centrifugal force, is thrown out at the outer diameter of the inlet. In addition, there is a loss due to slippage, that is, the vanes pass

the air without picking it up, thus pre-heating it before entrance into the impeller proper, and consequently more work must be put into the air in foot-pound per pound than would occur if the blades did not extend into the hub. A little calculation will show that the loss due to this cause exceeds that due to the crude method employed in blowers, the blades of which do not extend to the center of the shaft or hub, for with proper design of the casing at the inlet to the blades the slippage loss at light-load is almost entirely eliminated and the loss at full and overload is for all practical purposes negligible.

In answering the discussion by Mr. de Laval in which he criticizes the use of six stages for pressures as low as 10 or 20 lb., Mr. Rice in the closure to his paper, Commercial Application of the Turbine Turbo-Compressor,[1] stated that in the later type of blowers the number of stages had been reduced from six to three and higher efficiency attained " because of the higher speed and the smaller loss resulting."

The principal advantage which Rateau, Pokorny & Wittekind and Jaeger and other manufacturers of multiple-stage machines claim is that for the higher pressures the greater the number of stages, the more perfectly the gas can be cooled, and consequently the more nearly isothermal compression is approached, with the result that higher efficiency over-all is obtained. However, Mr. Rice states that a decrease of the number of stages for the same work done is accompanied by an increase of efficiency, although the amount of cooling surface and cooling is less in a blower of a higher number of revolutions per minute. Consequently, a fewer number of stages give a better efficiency in spite of the lesser cooling, than the greater number of stages. The tip speed of the impellers must be increased as the number of stages is decreased with the result that the tip speeds necessarily are not satisfactory with the built-up construction such as shown in Mr. Rice's Fig. 24, which, though supposed to be a built-up construction, does not show the method of securing the blades on to the disc.

Further in regard to Fig. 10, it may be remarked that both Mr. Rice and Mr. Moss have credited the partially free-vortex blower with from 80 to almost 85 per cent efficiency, which might have been obtained had the turbine driving the 40,000-cu. ft.

[1] Trans. Am. Soc. M. E., vol. 33, p. 381.

blower sufficient capacity to reach the load of maximum efficiency. The reason why the 30,000-cu. ft. blower did not reach a higher efficiency than the larger was due to an oversight in the design of the rotor of the 30,000-cu. ft. blower which caused the efficiency of the impeller alone to be very low, though both the 30,000 and 40,000-cu. ft. impellers had straight radial blades without any curvature at the blade entrance, and both blowers had exactly the same casing, except for the difference in the free vortex. Had a rotor of the same design as that of the larger machine been employed in the smaller, the efficiency would have easily exceeded 80 per cent.

Since the 40,000-cu. ft. blower showed that its efficiency at its most efficient load would be 80 per cent or better, Mr. Rice's criticism of a volute and forced vortex at the inlet, combined with straight blades, is not borne out by facts.

In general Mr. Rice's remarks about a flat characteristic being due to improper velocity conversion in the free vortex are not substantiated by facts, since when the other losses in the blower are considered, an efficiency of only 74 per cent requires a very high efficiency of the free vortex and as stated, this in the 30,000-cu. ft. blower was in excess of 90 per cent. Though the velocity conversion in the 40,000-cu. ft. blower was considerably less efficient than in the 30,000-cu. ft. blower, the efficiency of the larger impeller was considerably higher, the difference in impeller efficiencies is far more than sufficient to offset the gain in the efficiency of the free vortex.

Mr. Moss states that a rising pressure characteristic is absolutely necessary for a blower of high efficiency. The author, however, can construct a free-vortex blower which will have a rising pressure characteristic, flat or rapidly dropping characteristic, using radial blades in each case, and obtain the same efficiency simply by changing the proportions of the impeller according to the characteristic desired, but as has been previously pointed out, only a blower with a nearly flat or dropping characteristic is satisfactory.

Mr. Moss says that at light loads there is enormous friction in the free vortex because "a particle must make many revolutions before it gets out." There is of course more friction per unit mass of air in the vortex at light-loads, but this loss is not so serious as Mr. Moss thinks, and at full-load in a properly

proportioned blower, the friction loss is very small indeed. Mr. Moss rightly points out that as the load increases, the path of a particle constantly becomes shorter, until at full-load it makes only part of a revolution between leaving the tip of the blades and entering the volute or collecting passage. At full-load, there is no difference between a free vortex and a perfect guide-vane blower, except the free-vortex blower does not suffer the additional friction loss caused by the surface of the vanes, since at full-load the path of the particles leaving the impeller coincides with the form of the guide vanes, or should do so, and therefore at full-load, the presence of obsence of guide vanes will have little influence on the over-all efficiency. In other words, an ideal guide-vane blower would have movable and flexible vanes which could adjust themselves to the angle of discharge from the rotor, and bend themselves into the curve of a particle in a free vortex at each particular load, in which case, again, except for the friction of the air on the surface of the vanes, the guide-vane blower would be but a less perfect free-vortex machine with a flat pressure characteristic, if properly proportioned.

One of the faults with the guide-vane blower is that only for one rate of discharge are the vanes at the proper angle; at light loads the angle is too large: and at overloads the angle is too small and likewise at only one load can the guide vanes be of the proper shape. Thus, while a straight diffuser such as the down-stream end of a venturi meter may have a high efficiency for converting kinetic into potential energy, a curved diffuser or a straight diffuser cannot be very efficient except when it conforms to the natural undisturbed stream lines of the fluid entering.

The foregoing also applies still more rigidly to the short guide vanes as used by Pokorny & Wittekind, Escher, Wyss & Company and Jaeger. Short guide vanes make a large number necessary for a given diameter and a consequently increased loss due to large friction surfaces, a greater number of edges exposed to the air stream and the breaking up of the air into numerous streams of small cross-sectional area compared with the friction surfaces encountered. In a free-vortex blower the entire mass is kept solid, which is the reason that the friction loss is so much smaller at all loads than in any form of guide-vane machine.

Messrs. Rice, Moss and Crissey have little fault to find with

the discussion of the diffusion tube and apparently accept it as correct. Mr. Moss, however, has misunderstood it. He agrees with the theory, but incorrectly interprets it by saying that "as the volume passing through the blower changes so as to change the velocity at the beginning of the tube, the blower itself produces a pressure corresponding to the new conditions." This statement would be true if the velocity of the stream of air approaching the "beginning of the tube" varied directly as the volume, or in other words if the speed of the blower always varied directly as the volume, but at a constant r.p.m. the velocity of approach varies only slightly at the tips of the blades regardless of the volume delivered, and the writer was discussing the characteristics of the two types of blowers at constant speed. Furthermore, Mr. Moss will not obtain the conditions stated, namely, constant relation of velocity of approach and pressure of equilibrium, even with a constant volume regulator, since the pressure required with the same volume will vary over wide ranges, whereas the r.p.m, varies as the square root of the work done in foot-pounds per pound of air.

The writer was misunderstood in the statement in Par. 22, "for some fixed relation between the velocity of approach and final pressure ..... constant delivery is also possible." This applies only to the points of maximum efficiency of the diffusion tube, since it is obvious that as long as the pressure in the receiver R, "which is controlled by a valve, or other means," is kept below the pressure which gives maximum efficiency of the tube for the given velocity of approach, the pressure in the receiver will remain very nearly constant.

Mr. Moss uses the same example in regard to the conversion of kinetic energy that Mr. Rice uses, namely, the action of a venturi meter, but the author has pointed out the difference between the action of a venturi meter diffuser and the conditions under which it operates, and the conditions under which the diffuser of a blower operates. As previously pointed out, the error arising from such a comparison is due to the fact that whereas in the centrifugal blower the velocity of approach before the mouth of the diffusion tube is very nearly constant, in the case of the venturi meter the velocity of approach is always directly proportional to the flow through the meter. Furthermore venturi meters as ordinarily employed handle water which

is for all practical purposes incompressible. The pressure fluctuations which might be noticeable when used for the measurement of air would not be noticeable in the handling of water.

So long as a blower fitted with guide vanes operates at a point below its maximum efficiency for any given delivery and r.p.m., pulsations of any serious nature can be entirely eliminated, as was pointed out by Mr. Rice in his paper on the Commercial Application of the Turbine Turbo-Compressor. However, since the guide-vane blower has admittedly by the discussion of Messrs. Rice, Moss and Crissey, a less efficient conversion of velocity into pressure at light-load as well as loads in excess of that for which they are designed, and that in order to avoid fluctuations of pressure, the efficiency must be still further reduced, is sufficient evidence in itself to prove that a free-vortex blower, which is capable of attaining an efficiency of 75 to 80 per cent at full-load with rising pressure characteristic from full to no-load, is far more desirable than a blower fitted with guide vanes, which under any conditions whatsoever necessitates the use of a speed regulating mechanism in order to give it the slightly decreasing pressure characteristic obtained in a free-vortex blower at constant speed. In other words, where a very rapidly decreasing pressure characteristic is essential, it is evident that since the free-vortex blower has of itself a decreasing pressure characteristic at constant speed a smaller variation of speed is necessary in order to give any given slope of pressure characteristic than is required in the guide-vane blower. This means of course a higher efficiency of the driving turbine or motor.

Mr. Moss next takes up the mathematical part of the paper, showing how this can be very much simplified. The several reasons which he presents are perfectly correct. In such a deduction as Mr. Moss has given, for instance, of the centrifugal compression in the impeller, it would be difficult for the reader to understand the explanation unless he was already familiar with exactly what takes place in the impeller of a blower. The same applies to the deduction of what happens in a free vortex as it would be very simple to show that, since the velocity in the free vortex is inversely proportional to the radius it is evident for instance that if a point is taken at twice the radius of the impeller, the velocity would be one-half that at the blade tips, and

therefore, its energy one-fourth, whence three-quarters of the energy at the tips of the blades would have been converted into the form of potential energy as represented by an increase of pressure. The same also applies to the analysis of the diffusion tube for Bernouilli's theorem states that the velocity varies inversely as the area and consequently for an incompressible fluid (or small pressure variation in a compressible fluid), it is evident that if the mouth, or large end of the diffusion tube is twice the area of the inlet end, the velocity must be one-half that at the inlet, and consequently has kinetic energy only one-fourth as great as at the inlet. Since only one-fourth of the kinetic energy is left at the mouth of the diffusion, three-fourths of the kinetic energy must be converted theoretically at least into the potential form, namely, by a rise of pressure. The author would call Mr. Moss's attention to the fact that in the equation

$$Q = 6540 \frac{A\, T_2}{\sqrt{T_1}} \sqrt{(K+1)\, K}$$

the constant is not $60\sqrt{2\, g\, J\, C}$ since the mechanical equivalent of heat J does not appear in this formula. Also, in Mr. Moss's equation for the work done by adiabatic expansion, the mechanical equivalent of heat should be omitted.

Mr. Moss also gives a formula for the horsepower in which he uses the author's K the absolute inlet pressure and a constant, $H = \frac{P_2 K}{3330} \frac{\gamma}{\gamma - 1}$. The constant 3330 in this formula appears to be incorrect and since γ is essentially constant for all the so-called perfect gases, the author does not see why Mr. Moss did not include $\frac{\gamma}{\gamma - 1}$ in his constant 3330. Mr. Moss's criticism of the author's long equations is not justified inasmuch as the layman in order to see exactly the processes which are going on during the operations in a blower, must see these in the differential form. For those familiar with the actions in a blower, the shortened processes, of course, are equally clear. Had this part of the paper been published in its entirety, the criticism of the long formula would not have been necessary, as the author, in the main part of the text, even omitted the cancellation of similar terms of the numerator and denominator of the various equations in order that the reader could follow through in easy steps the derivation of the final equation.

Because of this criticism the author here presents the contracted formula relating to the adiabatic expansion and compression of air and curves of the value of $\left[\left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}}-1\right]=K$ on a scale sufficiently large that the value of K and the value of $\frac{P_1}{P_2}$ can be found with sufficient accuracy for all practical and experimental purposes, and can likewise be used for solving the equation for the pressure correction given in Par. 68. It will be necessary in this case to work backward from K to the value of $\frac{P_1}{P_2}$ on the diagrams, imagining a 1 in front of the decimal point of the values of K.

Mr. Crissey has criticized the author and stated that he has evidently compared the free-vortex blower with turbo-blowers of inferior design, and that sharp peak and rapid drop of efficiency on either side of the peak are apparently characteristic of poor design. However, the writer has failed to find any authentic tests of guide-vane blowers which show a smoother efficiency characteristic than that shown, in spite of the fact that some of the tests of guide-vane blowers which he has examined indicate an efficiency as high as 78 per cent.

Mr. Crissey states that "every builder of turbo-blowers, turbo-pumps and turbo-compressors would like to omit diffusion vanes because they add to the expense of production, but experience has shown that they are advantageous. Their use led to the introduction of high-pressure centrifugal pumps, etc." He will find, however, that there are other reasons for the use of the vanes, namely, the introduction of guide vanes as an easy means of overcoming difficulties which were at that time not really understood by designers, but perfectly well known to those sufficiently informed on the theory of centrifugal compressing and pumping apparatus.

Referring to Mr. Crissey's discussion of the impeller construction, he together with Messrs. Rice and Moss, apparently entirely misunderstood the author's meaning in regard to straight radial vanes and what was meant by "the lowest blade speeds."

For tip speeds less than 300 or 400 ft. per sec. built-up construction may be satisfactory provided the blades are not too

broad in axial direction so that the unsupported surface in proportion to the work done by one blade is not too great. Where the blade speed exceeds 300 or 400 ft. per sec., built-up construction may be satisfactory provided the blades are very narrow in an axial direction and that the work done per blade is small. Mr. Rice has referred to the fact that of the hundreds of machines which have been built in Europe only a few are in operation, and has suggested that this is due to the method of balancing employed by Rateau, but as a matter of fact Mr. Rice will find that most of the blowers which are not operated are out of commission because of improper impeller construction.

Mr. Crissey remarked that manufacturers who have employed milled-out construction have abandoned it and returned to the built-up construction, but he has omitted to state that this was done because the built-up construction is much cheaper than the solid construction. The author is familiar with a number of cases where impellers running at only a moderate speed of between 300 and 500 ft. per sec. have vibrated to such an extent as to loosen the riveting and wreck the machines. In speeds exceeding 500 ft. per sec. and any considerable blade width, except for the commercial reason of cheapness of manufacture, there is no logical excuse for using anything but the solid rotor construction.

Mr. Crissey states that he prefers the European method of testing to author's; that is, the measurement of the air at the intake of the blower instead of at the discharge, and gives as one of his objections, that it necessitates correcting the volume of air from the discharge pressure and temperature at the mouth of the nozzle to that of the atmospheric pressure and temperature. To one designing blowers so simple a problem should not present such great difficulty and so great a source of probable error.

Following is a standard clause of all blower contracts of The Westinghouse Machine Company, showing the method of conducting tests, and Mr. Crissey will note that the volume delivered by the blower is not only measured at the intake but at the discharge as well, and the volume as measured at the discharge must check within one-half of 1 per cent of the volume as measured at the intake. The writer believes this eliminates any chance of error.

METHOD OF TESTING HIGH PRESSURE CENTRIFUGAL BLOWERS

The method of test which shall constitute part of this contract will be the operation of the blower at constant speed. The volume of air handled and the efficiency of the blower will be calculated from the equations given on Drawing 64048 attached; the readings of pressure and temperature to be taken as shown in Fig. 29.

As shown in Fig. 29, the volume will be checked by three methods, viz.: the flow as calculated through a nozzle on the intake to the blower, flow as calculated from a nozzle on the discharge of the blower located approximately as shown in the drawing, and as a check against the volumes as measured from the intake and discharge nozzles, the volume will likewise be checked by the difference between the static pressure measured at the discharge, and the total (or static plus velocity pressure) as measured by a Pitot tube, as shown at the upper part of Fig. 29. The volume actually handled shall be considered as equal to the mean between the volume measured at the inlet nozzle and that measured at the discharge when the latter has been corrected to the inlet conditions, according to the formula given on Ddawing 64048. The pressure at the throat, or minimum section of the intake nozzle, shall be taken at four points as shown attached hereto.

In the intake a Pitot tube shall be inserted, as shown in Fig. 30, and readings taken at each 1 in. of the radius, the first reading being taken ½ in. from the side of the throat. The temperature shall be taken at four points at arbitrary radii, as indicated by the thermometer on Fig. 29.

The mean static pressure at the discharge in the blower and the mean temperature shall be taken by means of four thermometers and four pressure connections, arranged similarly to Fig. 50, except that Pitot tube readings need not necessarily be taken at this point.

The co-efficient of flow for the intake shall be taken as 0.995, and the co-efficient for the discharge shall be taken as 0.99.

If, without resorting to the Pitot tube readings, the volumes, when reduced to a common basis as calculated from the intake and discharge orifice, do not check within one-half of one per cent, both the intake and the discharge shall be searched by means of a Pitot tube, as indicated in Fig. 30, and other discharge co-efficients calculated from the Pitot tube readings.

As the intake nozzle and the discharge nozzle are of very considerably different diameters, if, assuming the above co-efficients, the flow reduced to a common basis checks within one-half of one per cent, this would in itself constitute a proof of the correctness of the method of measurement, since, if there is any considerable correction for the coefficient of contraction of flow through an orifice when constructed in accordance with the drawings attached, the co-efficient of contraction would vary considerably with the diameter, and consequently the flow, as calculated from two nozzles of different diameters, could not possibly check within the limits above described.

If the barometric pressure existing during the trials, and the temperature of the air at the inlet varies from that specified in the contract, the

correction of the discharge pressure for the barometric reading and the inlet temperature shall be made in accordance with the formula P^1,

$$P'_1 = P'_2\left\{\frac{T_2}{T'_2}\left[\left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}} - 1\right] + 1\right\}^{\frac{\gamma}{\gamma-1}}$$

this formula for correcting the discharge pressure being used only should

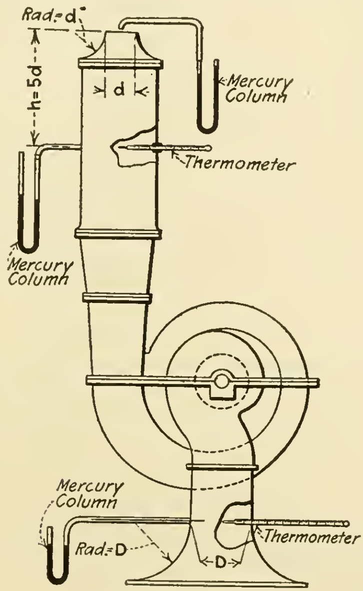

FIG. 29 DIAGRAMMATIC ARRANGEMENT OF CENTRIFUGAL BLOWER TESTING APPARATUS

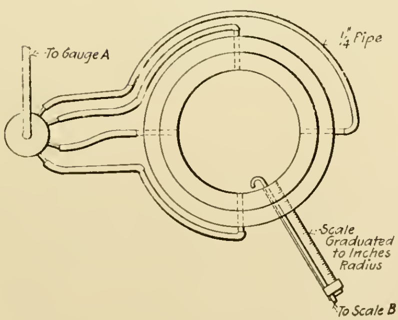

FIG. 30 PLAN VIEW OF BLOWER INLET

the pressure on test fall below that called for in the contract, the efficiency being independent of the temperature at the inlet.

In any blower operated continuously at no-load, whether of the guide-vane or of the free-vortex type, the temperature of the air rises owing to friction losses in the blower, and as the temperature rises the density of the air decreases. Consequently, since for a given tip speed or constant r.p.m., only a fixed number of foot-pounds of work per pound of air can be done in the impeller, there will be a rise and fall of pressure due to the fact that as the temperature increases, part of the air within the casing will back into the intake, and will be replaced by cooler air by mixing. This will again cause the pressure to increase owing to the greater density of the cooler air, and the blower to rise to a higher pressure than it can maintain; but it is only at no delivery that this phenomenon occurs in a free-vortex blower, whereas, unless run at an overload for a given r.p.m., this occurs at all loads on a guide-vane blower.

Mr. Crissey gives a formula for equivalent weight of air in pounds per second entering the blower inlet, but the author believes that he will find that this is rather more complicated than the contracted formula when used with the curves belonging to it. Apparently from the nomenclature employed by Mr. Crissey, it is evident that he follows the directions furnished with the license to build Pokorny & Wittikind's blowers.

The author wishes to thank Mr. Crissey for calling his attention to the errors in Par. 13, and in Fig. 10, as both the pressure and efficiency curve of the 30,000-cu. ft. blower should have been lettered 3600 r.p.m.

In regard to the symbol P in general throughout the paper, this refers to the static pressure, but it may also be used under some circumstances as a static plus the velocity head. P_2 is always the inlet pressure to the blower, or the inlet pressure of the impeller of any given stage of a multiple-stage blower under consideration, and T_2 is always the absolute temperature at the entrance to the inlet of the blower, or the inlet of any given stage of the multiple-stage blower under consideration.

Mr. de Laval refers to some works on blowers with which the author is familiar, but their discussion is impossible at this time owing to the fact that there are so many discrepancies, and in some cases, falsely assumed conditions employed in the various articles and books referred to, that space would not permit even of pointing these out.

Mr. de Laval states "that the experiments by Rateau, Parsons, etc., distinctly point to the rational design of diffusers as solving this problem." He refers to Parson's experiments and says that after building Parson blowers of the axial compression type he found that the centrifugal blower was more efficient and proceeded to produce similar blowers. The axial compression blower of Parson's depends entirely upon the velocity conversion in curved diffusion tubes, namely, the stationary vanes located between the moving vanes of the blower, and also in the moving blades. As the low efficiency of the Parson blower is well known, Mr. de Laval has selected a very poor reference in proving the efficiency of guide vanes.

He likewise says that the calculation of a centrifugal compressor is similar to that of a centrifugal pump and gives the formula $p = \frac{v^2 s}{2g}$. This same error occurs in the book of "Ostertag," to which Mr. Crissey referred and is absolutely incorrect, for anything but a very low pressure.

Mr. de Laval has evidently entirely overlooked the true meaning of the deduction of the author's equation

$$\frac{T_1 - T_2}{T_1' - T_2}$$

inasmuch as the derivation of this formula was simply to show that regardless of what method, or from what source the losses occurred, it still holds true. It was only to state this in differential form so that the processes at every point and instant could be appreciated by the reader that this deduction was made. It is evident that if the law of conservation of energy is granted, it is necessary that the heat put in at the shaft must appear as a sum of the heat reappearing as useful work plus the heat wasted in other ways. This in itself is a proof, but is not so easily understood.

Mr. de Laval states that this method of testing is not correct because of the fact that there is some radiation from the casing of the blower, and also some heat lost in the bearings which does not appear at the discharge of the blower. This is correct, but he will find that compared with the total heat energy going through the blower in a given time the small area exposed for radiation and loss of heat by convection and the power lost in the bearings is so small that it is within the limits of the errors

of observation in ordinary commercial tests. This is especially true on blowers designed like those of the Westinghouse Machine Company where the greater part of all the bearing friction heat equivalent is conducted by the metal to the intake, which warms the air, and where part of the radiation is eliminated due to the fact that the intake surrounds a large proportion of the casing of the blower. For these reasons, for all practical purposes this method, if carefully employed, is probably more accurate than measuring the horsepower and volume, pressure and calculating the efficiency from these quantities.

One serious objection, however, to the temperature method of determining the efficiency is that the greatest care must be taken to insure that warm air, as for instance from under the engine-room floor, does not enter the intake of the blower unless the blower is so constructed that it is possible to get the average temperature of the air after entering the inlet. This is the reason for the difference between the efficiency as measured from the b.h.p. input and the temperature method in the example of the blower tests given in the paper. The low efficiency shown by the temperature method was due to the fact that warm air in considerable quantities was drawn in from under the power house, whereas the inlet temperature was taken in the passage leading to the blower and the readings taken at this point were considerably lower than the average actual temperature of the air entering the blower. It was rather interesting in this particular instance to note that whether the temperature method showed a higher efficiency than the b.h.p. method, or vice versa, depended upon the direction of the wind prevalent at the time the test was being run, as this varied the amount of warm air drawn in from the power house basement.

Mr. Guy has entered upon a discussion of the relation of the impeller and casing. He puts forth the theory that the entire action of the air or fluid in a blower or compressor depends practically only upon the design of the impeller. Mr. Guy lays particular stress upon the shaping of the blade between the inlet and outlet, but the author believes that provided other dimensions of the rotor are properly made, the actual form of the curve between the inlet and outlet has very little influence upon the efficiency of the blower.

The author agrees with Mr. Guy in that any formula which

involves only the inlet and outlet angles of an impeller without other considerations will not give satisfactory results. Of all the works he has ever reviewed on the subject of the design of pumps or blowers with curved vanes, he has not found one formula which agrees with practice. As Mr. Guy says, the area of the passages through the impeller between the inlet and outlet determines its characteristics and its efficiency. That is the efficiency of the impeller alone.

However, Mr. Guy is mistaken as to the importance of the design of the impeller, since with a suitable design of casing and proper proportions of impeller it is possible to use vanes of any reasonable shape, either tipped backwards radially or forwards, and still obtain the same efficiency, provided that the proportions and design of the casing are suitable for the particular type of impeller employed. Mr. Guy is also in error in regard to the effect which the casing or its form has upon the performance of a blower, regardless of the type of impeller employed. The author has tests on low-pressure blowers which show that the characteristics of the impeller itself can be totally changed by a very slight alteration in the form of the casing. Likewise, the capacity at which the maximum efficiency occurs and the maximum capacity which can be obtained from the blower with a free discharge is determined by the casing more than by the impeller itself.

It may be interesting to note in this connection that the writer has run a very large number of tests on low-pressure blowers in which the actual static pressure at the tip of the blades was less than that at the inlet and the air entering the impeller or rotor revolved in the opposite direction to the rotation of the impeller. The explanation of this phenomenon, which so far as the author knows, has never been observed in any previous tests on centrifugal blowers, is due to the fact that the pressure head created by the impeller itself was not sufficient to balance the kinetic energy required to produce the velocity of entrance into the impeller, the difference between the pressure head created in the impeller and that necessary to cause the entrance into the impeller being produced entirely by the casing. In spite of this fact, an efficiency of over 65 per cent was obtained under this condition. The efficiency of the impeller itself being a minus quantity and the entire useful work being accomplished in free vortex. This

should also be sufficient proof to convince Messrs. Rice, Moss and Crissey of the efficiency of a free vortex when properly designed, and furthermore, this rotor had a decreasing or drooping pressure characteristic.

In regard to Mr. Guy's remark concerning "the blower described is the same as that which forms the subject of the discussion of R. N. Ehrhart on the paper on turbo-compressers[1] is simply an enlarged fan of the type as described and made by Professor Rateau some years ago," the author wishes to call his attention to the fact that the fan made by Professor Rateau some years ago was totally different from that of which Mr. Ehrhart spoke.

At this point it might be well to point out to Mr. Guy that in the opening paragraph of the author's paper, he stated he claimed no originality whatsoever for the matter presented. Mr. de Laval's statement that the influence of the shape of the casing was pointed out by Poillon in a book on Pumping Machinery about 30 years ago, is rather a recent reference as this matter was fully investigated by the late Lord Kelvin at a much earlier date and has been on record, but apparently there have been few engineers who have sufficiently understood Lord Kelvin's deductions to put them into practise.

Regarding Mr. Guy's Figs. 27 and 28 and his reference to the fact that two impellers with differently shaped vanes produced the same pressure at no-load was very interesting. The impeller with vanes curved backwards and that with the vanes curved forwards show distinctly that the box form of casing employed by Mr. Guy is extremely inefficient at light-load. With the vanes tipped backwards it is true that within reasonable limits, if the outlet is not choked in any manner by making the outlet angle sufficiently small and running at a high r.p.m. compared with the work done in order to reduce the disc friction or rotation losses, it is possible to get a very high efficiency without any means whatsoever of reconverting the final velocity into pressure. In fact, if it were not for friction, if the vanes made a zero angle with the tangent at the periphery, 100 per cent efficiency would be theoretically possible without any casing or other means of reconverting velocity into pressure. The speed for any pressure would however, have to be infinity in this case.

[1] Trans. Am. Soc. M. E. vol. 33, p. 396

Unfortunately, however, the tip speed required even in a radial-blade impeller to create any considerable air pressure is so high that curved vanes which make a small angle with the periphery are entirely out of the question for practical work. Mr. Guy has not given the efficiency of the impeller with the vanes tipped backwards. His b. h. p. and efficiency curves for the high-pressure impeller, e.g., the one with blades tipped forward, do not agree as there is a hump in the horsepower curve, whereas the efficiency and pressure curves are shown to be smooth. Some great phenomenon must have occurred at this point in order to produce such results, but on the face of it there does not seem to be any ground for thinking so.

In spite of the fact that at no-load there is theoretically no circulation of air through the impellers, one would expect that with the vanes tipped forward, due to the eddies which occur, a higher pressure would be obtained than with the blades turned backwards, though Mr. Guy has drawn his curves very nicely to agree with the theoretical case of no delivery when including the air which is revolving inside the impeller due to friction, the head created by any impeller regardless of the shape or form of the blades is exactly the same.

THE LUBRICATING VALUE OF CUP GREASES

By A. L. Westcott,[1] Columbia, Mo.

Non-Member

ABSTRACT OF PAPER

Cup greases are made by a process of saponifying animal or vegetable oil, as cotton seed, lard or tallow. To the soap thus formed is added mineral oil, sufficient to give the desired consistency. Manufacturers supply greases of several consistencies adapted to different conditions of lubrication, each being designated by a number.

2 While grease lubrication has a wide general application, it also has its own special field where it has a marked advantage over oil. This field is machinery in which the operation is intermittent, such as cranes and hoisting machinery. Grease cups of proper design will supply ample lubrication to the bearings of such a machine. They require no attention except to be filled with grease when empty and, if of the hand operated compression type, grease has to be forced into the bearing perhaps once or twice a day. No lubricant is wasted when the machine is not in operation, as is likely to be the case if sight feed oil cups and liquid lubricant are used.

3 It was the purpose of the investigations which form the basis of this paper to test a number of greases under a variety of conditions as to bearing pressure, temperature, and method of application, for coefficient of friction and general suitability as a lubricant.

DESCRIPTION OF TESTING MACHINE

4 Tests for the coefficient of friction were made upon a Golden oil testing machine. Fig. 1 is a general view of this machine, and the side and end elevations are shown in Fig. 2. The bearing consists of a babbitted sleeve which is fitted to a shaft *H*, Fig.

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Presented at the St. Louis Meeting, February 5, 1913, of The American Society of Mechanical Engineers. The complete paper may be consulted at the rooms of the Society, 29 West 39th Street, New York.

2. This shaft runs in roller bearings F and is driven by a motor through the coupling L. The motor is arranged with a reversing switch so that it may be run in either direction as desired. A cast-iron beam A is bored out at the center of its length to fit the bearing, to which it is fastened by screws. The ends of this beam are circular arcs struck from the shaft center. Flexible bands C are attached to A and support the weights B by means of

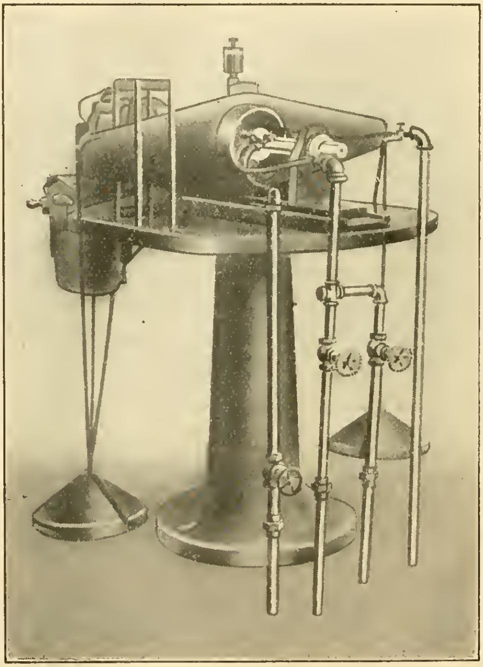


FIG. 1 GOLDEN OIL TESTING MACHINE

which the load on the bearing is applied. The casting which forms the bearing is cored out so as to provide a space for a jacket in which cold or hot water or steam may be circulated in order to control the temperature. At D a spring balance is supported upon four vertical rods that are screwed into the machine top. This balance is connected by a thin strip of spring steel to the post with screw adjustment at G. The steel strip leads over a part M, cast on the upper side of A, and machined to form a circular arc, the center of which is the center of the shaft. The radius of this arc is 6 in. and the height of the balance is such that it exerts a pull always in a horizontal direction. The weight

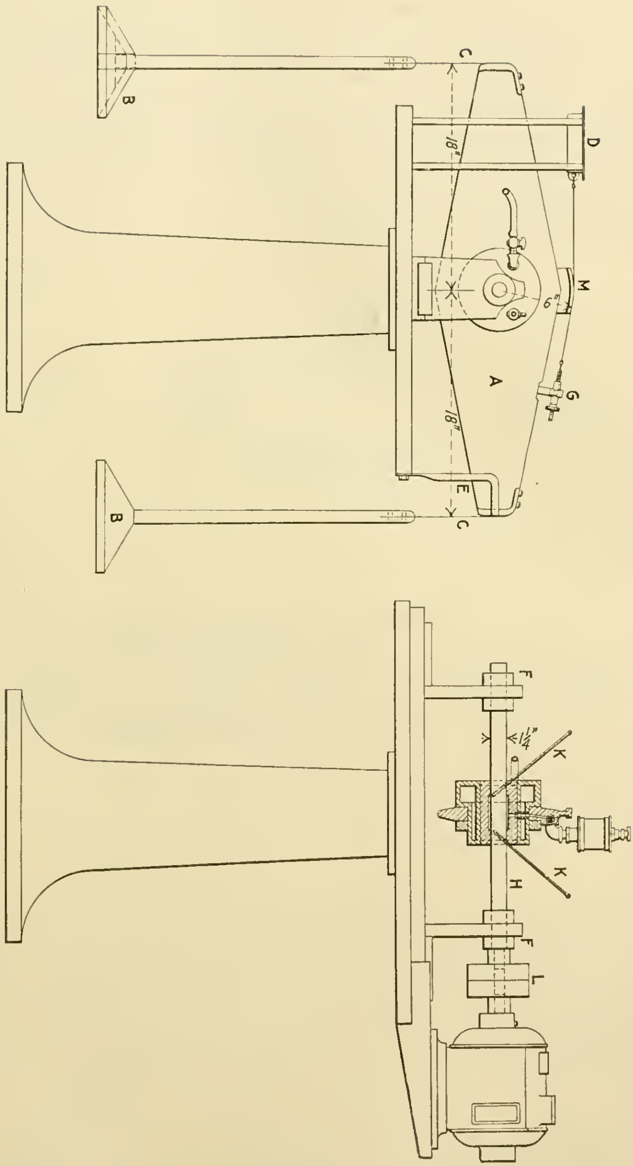


Fig. 2 Golden Oil Testing Machine

on the end of the beam opposite to D must be made a little greater than that on the adjacent end, so that a positive pull will always be exerted in whichever direction the motor is running. A pointer E, attached to one end of the table top, enables the operator to bring the beam to any desired angular position. Holes are drilled in each end of the bearing for the insertion of thermometers K, the bulbs of which are brought close to the side of the journals, so as to obtain an indication of the bearing temperature as nearly correct as possible.

5 As originally constructed, the machine differed in several details from that shown in Fig. 2.

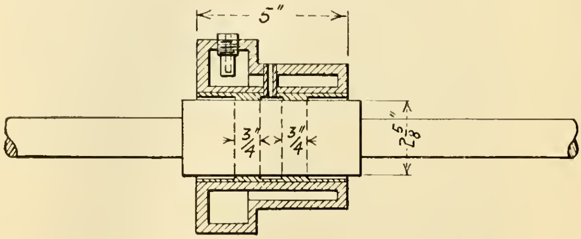


FIG. 3 BEARING FOR GREASE TESTING

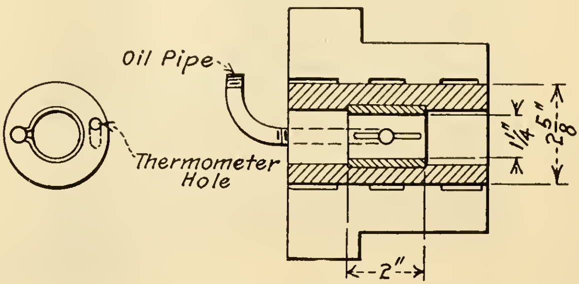


FIG. 4 BEARING FOR GREASE TESTING

6 The bearing as supplied by the makers was 2⅝ in. in diameter, by 5 in. long. With the largest load that the suspending chains would safely carry this gave only about 50 lb. per sq. in. of projected area. It was desired to carry the bearing pressures much higher than this. The length of bearing was therefore reduced to 1½ in. as shown in Fig. 3, there being two rings of ¾ in. in length each. The temperature was determined by a thermometer inserted into the jacket as shown in Fig. 3, which also shows the manner of applying the lubricant.

7 The bearing of Fig. 3 was not satisfactory. It appeared

that the proportion of length to diameter was bad, at least for grease lubrication. The grease was applied by means of a hand operated grease cup of the compression type. The counterbore between the two bearings, where the grease was forced in, was large enough to form a reservoir, and it was thought that the grease would feed in so as to maintain constant lubricating conditions. This did not prove to be the case. After an application of grease the friction, momentarily reduced thereby, would begin to increase steadily. Under these conditions a plot of friction against time would look like the profile of a rip saw; a series of lines inclined more or less steeply to the horizontal, and connected by verticals where the grease cup was operated.

8 With a view to obtaining a more satisfactory form of bearing, the change indicated by Fig. 4 was made. The diameter was reduced to 1¼ in. and the length increased to 2 in. A sleeve made to fit the old bearing was bored out and babbitted to this size. The lubricant was applied at one side through a hole running lengthwise of the sleeve and was distributed along the journal by a groove, as shown in the figure. A hole was drilled for the insertion of a thermometer close to the journal. The temperature was controlled by the same water jacket as was used at first (Table 2).

CLASSIFICATION OF TESTS

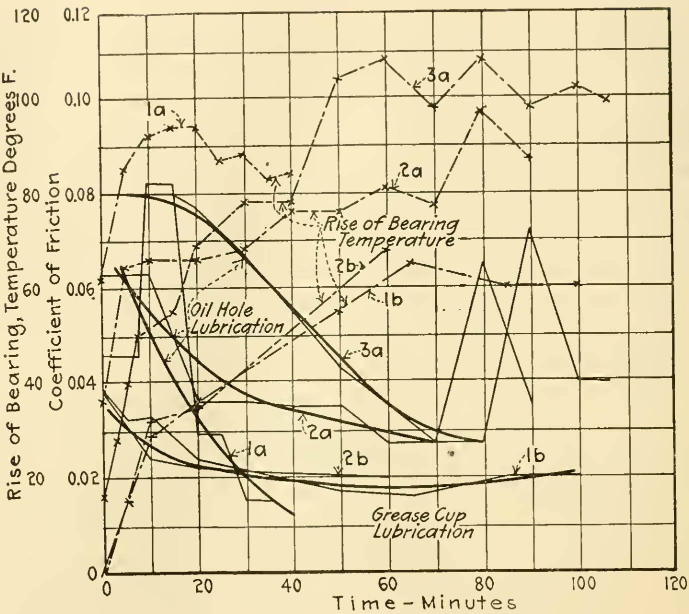
9 Three series of grease tests are included in this paper and in addition a series of oil tests was run. The grease tests will be classified as follows:

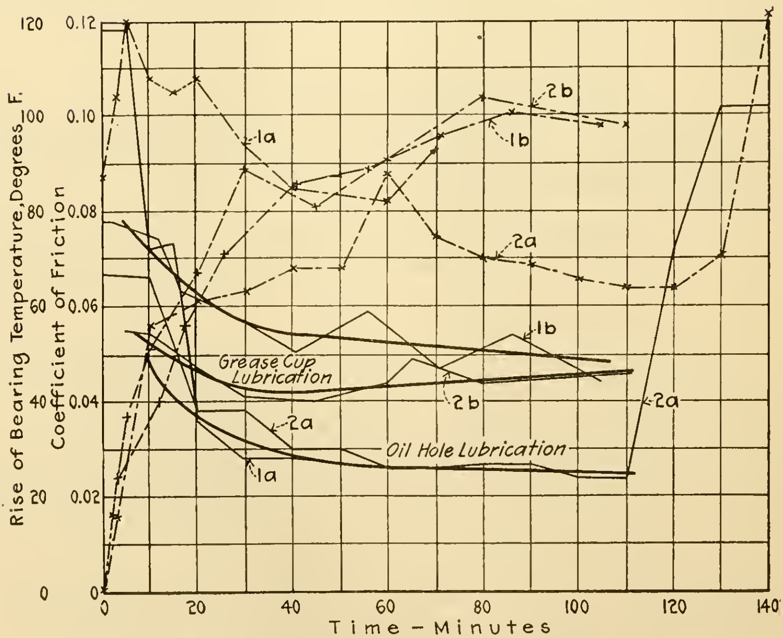
A Tests to determine the coefficient of friction of cup greases of different densities, using hand operated grease cup, with intermittent feed, the bearing of Fig. 3 being employed.

B Tests with the same objects as in series *A*, but with the bearing of Fig. 4 employed, and for the most part using a grease cup having a constant feed.

C A series of tests with six different greases to determine their behavior when applied in a grease cellar on top of the journal, with a view to their flowing into the bearing by gravity when warmed.

10 Greases from two makers designated as *X* and *Y* were tested in series *A* and *B*; greases from six different makers, designated by numbers 1 to 6, were tested in series *C*.





FIGS. 5 AND 6 GREASE CUP AND OIL LUBRICATION COMPARED

11 The consistency of the greases designated by X is indicated by numbers: No. 00 being the hardest; No. 6 a semi-liquid, and the other numbers forming a graded series between. Greases designated by Y are likewise numbered, but their hardest grease has the highest number, while No. 1 is the softest, almost a semi-liquid, at ordinary temperatures; No. 5 Y is of about the same consistency as No. 00 X.

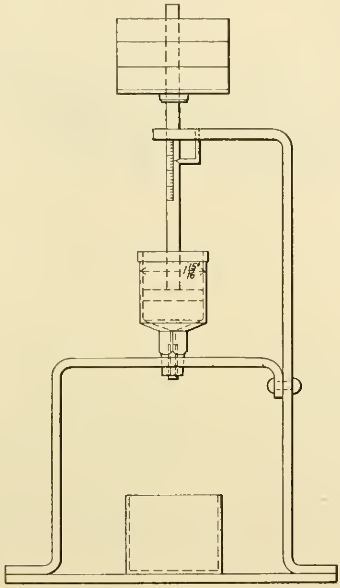


FIG. 7 APPARATUS FOR TESTING VISCOSITS OF GREASES

12 The greases of series C may be described as follows:

No. 1 soft spongy fibrous in appearance, bright yellow color

No. 2 hard bright yellow in color

No. 3 soft, dark brown in color

No. 4 very hard, light brown color

No. 5 extremely hard, looks and smells like soap

No. 6 a graphite grease, soft, black

DESCRIPTION OF TESTS

13 The tests upon each grease in series A and B were carried out as follows: The load on the bearing was varied for each grease through a range of 46 to 148 lb. per sq. in. in series A, and 53 to 154 lb. in series B. For each load the test was made at temperatures varying through a wide range; beginning the test

at a low temperature, which was gradually increased by successive increments as the test proceeded. During the first three tests of series *A*, steam was not available for use in the bearing jacket, the elevation of temperature in these cases being due to the heat generated by friction. In series *B*, and in other tests of series *A*, however, the temperature was controlled by either water or steam in the jacket. The tests show in each

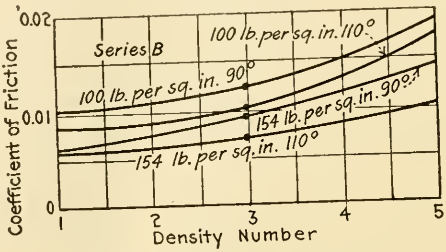


FIG. 8 FINAL SET OF DERIVED DATA FOR *B* GREASE

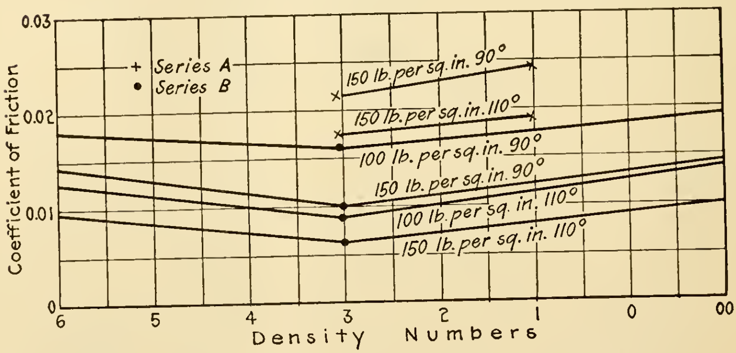


FIG. 9 FINAL SET OF DERIVED DATA FOR *A* GREASE

case the effect of rising temperature upon the coefficient of friction.

14 The results of the tests of one grease of series *A* are presented in Table 3, an ordinary engine oil, Table 4, being taken for the purpose of comparing it with grease as a lubricant under the same conditions. The tests of one grease of series *B* are found in Table 4 and Figs. 12 and 13.

15 For series *A* and *B* the plot was made of ϕ vs. bearing temperature. From these curves were derived the ordinates necessary for the next set of curves, ϕ vs. load, pounds per square inch on the bearing. Each of these was plotted for a constant temperature, curves for two or more temperatures being employed.

TEST DATA

16 All the tests of series C were made at one bearing pressure, 114 lb. per sq. in. of projected area of journal. These tests were run upon the bearing shown in Fig. 3. Two oil holes 1/4 in. in diameter were drilled through the bearing sleeve at angles of 30 deg. above the horizontal and on opposite sides of the vertical center line. To perform a test a measured quantity of grease was placed in the holes, the bearing was loaded to the desired pressure, and the test was started and continued without applying any additional lubricant until the lubrication failed. Neither water nor steam was circulated through the jacket space, and the rise of temperature, therefore, was due solely to heat generated by journal friction.

17 For the purpose of comparing this method of applying the grease with forced lubrication, tests were made of the same grease at the same bearing pressures, but feeding the grease by means of a compression grease cup.

18 The curves of this series were plotted differently from those of A and B (Cp. Figs. 8 to 11). Since the length of time a given test was continued without renewal of the grease in the oil holes is an important factor in determining the value of each grease, time was plotted as abscissae, and ϕ and rise of bearing temperature as ordinates. Each curve set shows the complete test of a grease, comprising one, two or three runs made on different days.

19 Figs. 8 and 9 show the final set of derived data as to series A and B. For a selected bearing pressure and temperature, the values of ϕ for each grease were plotted against the grease numbers as abscissae, the idea being to show the most advantageous grease consistency for a given condition. Plots were thus made for two pressures, and for two temperatures for each pressure.

20 An inspection of the tables and curves brings out some well defined relations. The values of the coefficient of friction shown in series A, made upon a bearing of large diameter and small length, are greatly in excess of values for the same grease when tested on the bearing shown in Fig. 4, series B; for example, compare Tables 2 and 3, at same loads and temperatures. As has been stated before, the large and short bearing consisting of two lengths of 3/4 in. each proved to be a poor form for grease lubrication. The film of lubricant seemed to have very little endurance, and the only way to get results, particularly with the

denser greases, was to force in grease frequently. Another difference in conditions between the tests of series A and B is the difference in velocity of journal. In series A the surface speed of journal was about double that of series B. The relations between speed of journal and coefficient of friction are discussed in Par. 26.

21 The tests of series C indicate that generally the oil hole method of applying grease to the bearing is inferior to the method of forcing it in by means of a grease cup, the coefficients of friction in the former case being much larger than in the latter. An exception is noted in case of grease No. 4, where the advantage lies with the oil hole method. If instead of a small oil hole, a grease reservoir extending the length of the journal had been used, it is possible that the results of the comparison might be different.

22 The best results so far as producing constant and uniform conditions of lubrication are concerned, were obtained when using a grease cup with a plunger actuated by a helical spring so as to give a constant feed. When adjusted to feed steadily and uniformly, the coefficient of friction at a given load and temperature remained about constant. With the intermittent feed of the hand operated grease cup, results in this regard were not so good. In many of the tests where observations were taken immediately after feeding the grease and at 1-minute intervals thereafter, the friction was seen steadily to increase even with the bearing of the form of Fig. 4, and to decrease again to its former value upon again forcing in grease. This is illustrated by the abstracts from the original log of tests of B greases No. 5, given in Table 1. It will be noticed that the variation in friction referred to is much more marked at low temperatures than at high ones, presumably because the grease flows better when hot.

23 The tests of engine oil, Table 3, which are inserted for the purpose of comparison of oil with grease, were run on the bearing shown in Fig. 3 (Cp. also Figs. 5 and 6).

24 The formula for coefficient of friction is deduced as follows. Let

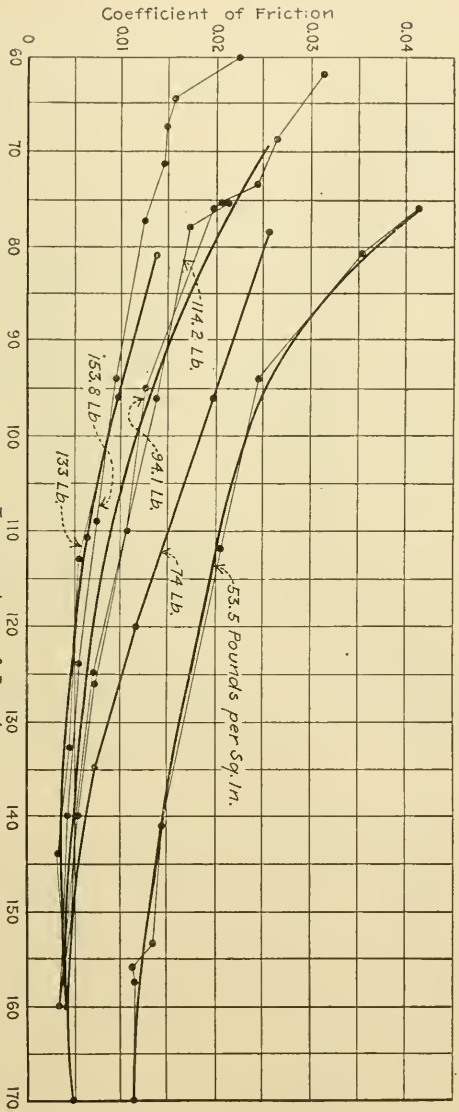
W = total load on the bearing, pounds

P_1 = pull on the spring balance when running in a clockwise direction, pounds

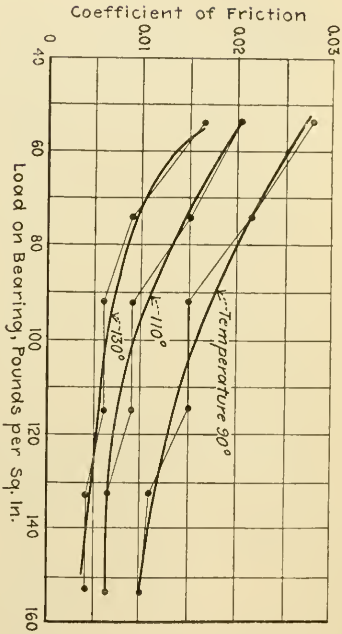
P_2 = pull on balance when running anti-clockwise, pounds

D = diameter of journal, inches

ϕ = coefficient of friction



Coefficient of Friction
0
0.01
0.02
0.03
0.04
60
70
80
90
100
110
120
130
140
150
160
170
Temperature of Bearing
114.2 Lb.
153.8 Lb.
94.1 Lb.
133 Lb.
74 Lb.
53.5 Pounds per Sq. In.



Coefficient of Friction
0
0.01
0.02
0.03
40
60
80
100
120
140
160
Load on Bearing, Pounds per Sq. In.
130°
110°
Temperature 90°

$$\phi W \frac{D}{2} = \frac{P_1 - P_2}{2} 6$$

$$\phi = (P_1 - P_2) \frac{6}{W D}$$

For any load W, the constant $\frac{6}{W D}$ may be computed once for all, and the formula takes the form

$$\phi = K (P_1 - P_2)$$

25 The effect of a rise of temperature upon the coefficient of friction is almost always the same. The curves show this very clearly. The fluidity of a lubricant is increased by warming it, and its viscosity is decreased. This results in decreased friction up to that point where the bearing pressure is sufficient to overcome the tenacity of the oil film, so that there is contact between the rubbing surfaces. The tests do not indicate that, within the limits of bearing pressure which obtained, there is any disadvantage or danger of cutting the bearing incident to a temperature of 150 deg. fahr. In some instances the temperature was carried as high as 200 deg. and as long as there was an ample supply of lubricant to the bearing, no harmful effects were noted. The "hot box" of practice occurs because the lubrication of the bearing has failed; the former being the effect of increased friction due to the latter. There is nothing intrinsically objectionable in a bearing temperature much higher than is commonly permitted in practice, if good lubrication obtains; and these experiments show that much may be gained in the way of decreasing the lost work of friction.

SPEED OF JOURNAL AND COEFFICIENT OF FRICTION

26 An effort was made to determine the relation between the speed of journal and the coefficient of friction. In his tests upon lubricating oils, Beauchamp Tower showed that for a given oil tested at a constant temperature, the coefficient of friction, where there was perfect lubrication, varies directly as the square root of the surface speed of the journal, and inversely as the pressure per square inch of projected area. That is

$$\phi = K \frac{\sqrt{S}}{w} \quad \text{[1]}$$

S = surface speed of journal, feet per minute

w = load on bearing, pounds per square inch of projected area

TABLE 1 ABSTRACTS FROM LOG TESTS OF *B* GREASES NO. 5 DENSITY

Load on Bearing, 74.1 Lb. per Sq. In.

Time	Spring Balance P_1 Lb.	Spring Balance P_1 Oz.	Spring Balance P_2 Lb.	Spring Balance P_2 Oz.	Bearing Temperature, Deg. Fahr.	Coefficient of Friction ϕ	Remarks
11.33	*7	8	....	....	76	0.0244	Readings marked *were taken immediately after forcing grease into the bearing
11.35	7	9	....	....	79	0.0276	
11.36	....	....	....	....	....	Reversed motor	
11.38	....	....	*6	9	80	0.0244	
11.39	....	....	6	8	80	0.0276	
11.40	....	....	6	7	80	0.0310	
11.40	....	....	*6	9	81	0.0244	
11.46	....	....	6	7.5	82	0.0293	
11.47	....	....	6	7	82	0.0310	
11.47	....	....	*6	11	82	0.0210	
11.57	....	....	6	5.25	83	0.0396	
11.57	....	....	*6	11.5	....	0.0201	
12.00	7	11.5	....	....	....	0.0325	
12.02	7	12.5	....	....	82	0.0350	
12.02	*7	8	....	....	....	0.0210	

Second Test at Same Load, but at Higher Temperatures

Time	Spring Balance P_1 Lb.	Spring Balance P_1 Oz.	Spring Balance P_2 Lb.	Spring Balance P_2 Oz.	Bearing Temperature, Deg. Fahr.	Coefficient of Friction ϕ	Remarks
5.26	7	6.5	....	....	110	0.0178	
5.26	*7	5.5	....	....	....	0.0146	
5.29	7	6	....	....	118	0.0162	
5.29	*7	5.5	....	....	....	0.0146	
5.30	....	....	6	12	120	0.0162	
5.32	....	....	6	12	....	0.0162	
5.32	....	....	*6	12.5	....	0.0146	
5.40	....	....	6	10	160	0.0228	
5.40	....	....	*6	10	160	0.0228	
5.42	7	8	....	....	164	0.0236	
5.43	7	7.5	....	....	160	0.0220	
5.46	7	8	....	....	158	0.0236	
5.47	8	0	....	....	....	0.049	Unsteady
5.47	*7	7.5	....	....	....	0.0220	
5.52	*7	10	....	....	185	0.026	
5.53	7	10	....	....	190	0.0260	
5.54	7	9.75	....	....	....	....	
5.55	....	....	6	10	....	0.0260	
5.55	....	....	*6	10	190	0.0260	
6.01	....	....	6	10	....	....	

K = coefficient, having different values for different lubricants, and for the same lubricant at different temperatures

From the observed values of S, w and ϕ in the tests of series A and B, the values of K were computed by substituting in equation [1], and were plotted against the corresponding temperature of the bearing. Fig. 10 shows the results of these plots for the X greases. Greases of different densities and series are distinguished by different forms of mark, so that the table from which each point came may be identified. Curves AB

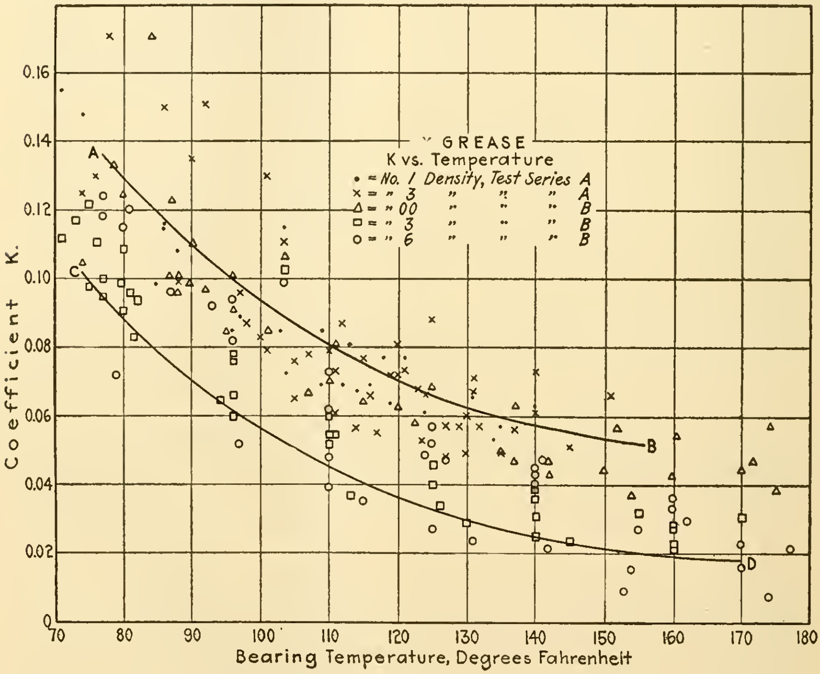


FIG. 10 BEARING TEMPERATURE AND COEFFICIENT OF FRICTION CURVE

and CD bound the areas above and below and represent the extreme values of K. It will be noticed that the plots for the denser greases in general, lie towards the upper curves, CD; and the softer ones nearer the curves AB.

27 It was desired to find the relation between K and the bearing temperature. expressed in the form of an equation which might be of general application. For each of the four curves, the points were replotted on logarithmic cross-section paper. Fig. 11. It appears from an inspection of the figure that K may

be expressed in terms of the temperature by an equation of the form

$$K = \frac{M}{t^n}$$

where M = a constant; t = bearing temperature, deg. fahr.; n =

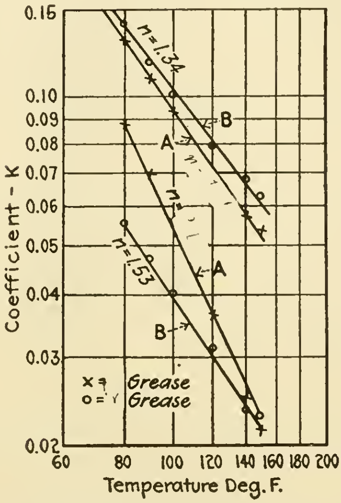


FIG. 11 K-BEARING TEMPERATURE CURVES PLOTTED ON LOGARITHMIC CROSS-SECTION PAPER

an exponent. The following values for these numbers are found from the logarithmic plots:

Greases X, curve AB $\quad K = \frac{78}{t^{1.46}}$

curve CD $\quad K = \frac{1370}{t^{2.19}}$

Greases Y, curve AB $\quad K = \frac{49}{t^{1.34}}$

curve CD $\quad K = \frac{42}{t^{1.53}}$

TESTS OF GREASE DENSITY

28 Lubricating oils are compared by certain physical tests. Prominent among these is the test for viscosity which is determined by a viscosimeter, several forms being in common use. One consists of a vessel for the oil surrounded by a space which

may be filled with water for the purpose of controlling the temperature. At the bottom of the vessel is a nozzle, through which a measured quantity of oil is permitted to flow. The viscosity is proportional to the time required to flow through the nozzle.

29 It seemed to the author that a similar scheme might be employed for comparing greases as to their consistency or density. Since grease is a solid and will not flow of itself, some compulsion must be used to force the grease through the nozzle. After preliminary experimentation an apparatus, shown in Fig. 7, was constructed which consisted of an ordinary grease cup supported upon an iron framework. A plunger was made to fit the cup, and to insure perfect freedom of motion the plunger was made slightly spherical. The plunger rod was carried through a guide, and supported weights placed upon its upper end. A scale graduated in twentieths of an inch was scribed on the rod, so that the time of descent over a measured distance might be noted. A nozzle of about ¼ in. in diameter was placed in the bottom of the cup.

30 Experiments with this instrument gave results that were decidedly surprising. It was found that the density of a given grease, as indicated by this means, is a very variable quality. Successive passages of the same grease gave constantly decreasing lengths of time for the same distance. The grease became softer and more fluid by the process of forcing it through the nozzle. This was particularly true of the harder greases. After several passages, the grease becomes oily in appearance. The change may be due to a more thorough mixing of the ingredients composing the grease. The results of a number of tests with this instrument follow:

DENSITY TEST, *X* GREASE, NO. 1 DENSITY

31 The same grease sample was passed repeatedly through the nozzle. The weight on the plunger was 20 lb.; temperature of grease, 71 deg.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Seconds to descend 1 in.	3750	235	95	66.2	57.4	36	27.2	23	19	19	16	24	14

The time became nearly constant after eight passages; the mean of Nos. 9, 10, 11, 12, 13 is 18.2 seconds.

32 The second test was made several days later, on the same grease sample as the preceding; load on plunger, 20 lb.; temperature of grease, 68 to 72 deg.

No.	1	2	3	4	5	
Seconds to descend 1 in.	17	12.6	14.2	13.8	14	mean time of last four, 13.6

33 The load was changed to 10 lb. and continued on the same grease sample as above; temperature of grease, 62 to 65 deg.

No.	1	2	3	4	
Seconds to descend 1 in.	572	670	597	593	mean time, 608

DENSITY TEST, Y GREASE, NO. 3 DENSITY

34 A sample of the grease was passed through the nozzle 18 successive times with weights of 20, 15 and 10 lb. The temperature of the grease was 82 deg. at the start, increasing to 92 deg. at the end.

LOAD, 20 LB.

No.	1	2	3	4	5	6	7	
Seconds to descend 1 in.	50	17.4	13	3.4 (?)	6.4	6.8	5.2	mean time of last four, 6.1

LOAD, 15 LB.

No.	8	9	10	11	12	13	
Seconds to descend 1 in.	15.8	16	12	11.4	11.6	9.6	mean time of last four, 11.1

LOAD, 10 LB.

No.	14	15	16	17	18
Seconds to descend 1 in.	159	131	129.6	97.8	95

DENSITY TEST, GREASE SERIES *B*, NO. 1

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Load, lb.	10	5	5	5	5	5	5	5	4	4	3	3	3
Seconds to descend 1 in.	3.2	23.6	31	18	27.4	25	23.8	19.8	57	59.4	273	250	267

35 Tests Nos. 2, 3, 4 and 5 were made on successive samples of grease taken from the can. Nos. 6 and 7 were repetitions of grease that had been passed through once. Similarly, Nos. 11 and 12 were new grease, while No. 13 was the second passage. It will be noted that, for this very thin grease, no great change occurs with successive repetitions of the test on the same sample. The time for No. 6 is almost exactly the same as the mean of the preceding four; and No. 13 is close to the mean of Nos. 11 and 12.

36 The consistency of grease as shown by the experiments described above becomes nearly constant after several passages through the apparatus at a constant load; but it appears that when the load is decreased, the grease again requires a number of passages under the new condition before coming to a constant condition of consistency. It is interesting to note the great effect

produced in the time of flow of the grease by a small change in the weight. Thus, in the last test, *Y* grease, No. 1, the time was increased about 450 per cent by decreasing the load from 4 to 3 lb.

CONCLUSIONS

37 Grease lubrication compares favorably with oil where the form of bearing is such as to favor the retention of the film of lubricant, and provision is made for an ample supply to the bearing. But, as shown by the experiments of series *A*, oil will give better results in case of a short bearing in proportion to the diameter.

38 Grease of soft consistency is a much better lubricant than the harder densities of the same grease. The advantage of the softer grease is especially marked at low temperatures, such as usually obtain in a well lubricated bearing.

39 The best method of applying grease to a bearing is by forced feed and a constant rate of flow. This agrees with the best practice in oil lubrication where the bearing is flooded with oil, which passes to a filter and is used again. The drawback in case of grease is the cleaning it after it has once passed through the bearing so that it can be used again. Intermittent application of grease means irregularity in the value of the coefficient of friction.

40 Grease cups with spring actuated plungers are designed to give a constant flow of grease. They are far from accomplishing this purpose, however. When such a cup is full of grease, the spring is compressed to its fullest amount, and the pressure upon the grease is, therefore, much greater than when the cup is nearly empty. Provision is made to regulate the flow by means of a small cock placed in the outlet of the cup, but this needs adjustment as the cup empties, and is apt to be neglected. The experiments upon grease consistency show what a great difference in flow is produced by a small change in the pressure upon the grease. A design of cup is desirable which will deliver the grease at a constant rate from the time it is filled until it is empty.

TABLE 2 *X* GREASE, NO. 3 DENSITY

SERIES *B*: LOADS OF 53.5 TO 153.8 LB. PER SQ. IN.; DIAMETER OF JOURNAL 1¼ IN., LENGTH 2 IN.; GREASE CUP USED WITH SPRING ACTUATED PLUNGER

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Load on Bearing 53.5 Lb. per Sq. In.; Surface Speed of Journal 405 Ft. per Min.			
1	76	0.0414	Room temperature 72 deg.
2	80	0.0342	
3	81	0.0358	
4	82	0.0352	
5	92–96	0.0268	
6	94–97	0.0246	
7	95	0.0218	
8	110–114	0.0190	
9	111	0.0213	
10	111	0.0213	
11	124	0.0173	
12	125	0.0185	
13	126	0.0168	
14	141	0.0145	
15	141	0.0134	
16	140	0.0151	
17	154	0.0134	
18	156	0.0112	
19	157	0.0117	
20	170	0.0101	
21	168	0.0106	
22	170	0.0140	
Load on Bearing 74 Lb. per Sq. In.; Surface Speed of Journal 395 Ft. per Min.			
1	78	0.0276	
2	79	0.0252	
3	80	0.0244	
4	95	0.0187	
5	96	0.0199	
6	97	0.0211	
7	120	0.0122	
8	119–122	0.0134	
9	120	0.0097	
10	135	0.00813	
11	134	0.0069	
12	135	0.0065	
13	152	0.0049	
14	155	0.0049	
15	155	0.00406	
16	168–171	0.0041	
17	171	0.0053	
18	171–189	0.0057	

TABLE 2—(*Continued*)

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Load on Bearing 94.1 Lb. per Sq. In.; Surface Speed of Journal 380 Ft. per Min.			
1	61	0.0312	Room temperature 67 deg.
2	69	0.0262	
3	73	0.0242	
4	75	0.0204	
5	76	0.0198	
6	96	0.0131	
7	95	0.0121	
8	95	0.0124	
9	110	0.0086	
10	111	0.0115	
11	100–110	0.0127	
12	124	0.0079	
13	126	0.0064	
14	125	0.0067	
15	143	0.0048	
16	141	0.0054	
17	139	0.0054	
18	161	0.0045	
19	160	0.0042	
20	160	0.0048	
Load on Bearing 114.2 Lb. per Sq. In.; Surface Speed of Journal 390 Ft. per Min.			
1	75	0.0212	Room temperature 67 deg.
2	77	0.0173	
3	78	0.0171	
4	79	0.0171	
5	96	0.0145	
6	96	0.0137	
7	96	0.0123	
8	108–111	0.0123	
9	112	0.0094	
10	110	0.0094	
11	127	0.0073	
12	125	0.0068	
13	125	0.0068	
14	140	0.0059	
15	140	0.0052	
16	140	0.0052	
17	159	0.0039	
18	161	0.0037	
19	160	0.0039	

TABLE 2—(*Continued*)

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Load on Bearing 133.4 Lb. per Sq. In.; Surface Speed of Journal 390 Ft. per Min.			
1	80	0.0162	
2	83	0.0119	
3	80	0.0126	
Load on Bearing 133.4 Lb. per Sq. In.; Surface Speed of Journal 390 Ft. per Min.			
4	97	0.0090	
5	96	0.0104	
6	96	0.0099	
7	114	0.0061	
8	113	0.0052	
9	113	0.0052	
10	131	0.0049	
11	130	0.0043	
12	132	0.0038	
13	144	0.0038	
14	146	0.0034	
15	145	0.0034	
16	158–162	0.0038	
17	161	0.0043	
18	161	0.0043	
Load on Bearing 153.8 Lb. per Sq. In.; Surface Speed of Journal 390 Ft. per Min.			
1	56	0.0285	Room temperature 62 deg.
2	60	0.0223	
3	64	0.0156	
4	67	0.0148	
5	71	0.0145	
6	77	0.0121	
7	93	0.0098	
8	94	0.0103	
9	95	0.0090	
10	108	0.0074	
11	108	0.0070	
12	110	0.0070	
13	123	0.0060	
14	125	0.0055	
15	124	0.0059	
16	139	0.0049	
17	140	0.0047	
18	141	0.0041	
19	158	0.0035	
20	160	0.0037	
21	160	0.0037	

TABLE 3 *Y* GREASE, NO. 2 DENSITY

SERIES *A:* LOADS OF 46 TO 85 LB. PER SQ. IN.; DIAMETER OF JOURNAL $2\frac{5}{8}$ IN., LENGTH $1\frac{1}{2}$ IN.; COMPRESSION GREASE CUP USED WITH INTERMITTENT FEED OF THE LUBRICANT

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Load on Bearing 46 Lb. per Sq. In.; Surface Speed of Journal 800 Ft. per Min.			
1	70	0.0504	
2	80	0.0460	
3	82	0.0421	
4	90	0.0400	
5	99	0.0340	
6	123	0.0355	
7	140	0.0378	
8	180	0.0300	
Load on Bearing 72 Lb. per Sq. In.; Surface Speed of Journal 725 to 800 Ft. per Min.			
1	69	0.0365	
2	71	0.0330	
3	83	0.0294	
4	95	0.0292	
5	115	0.0240	
6	147	0.0252	
7	208	0.0232	
Load on Bearing 85 Lb. per Sq. In.; Surface Speed of Journal 700 Ft. per Min.			
1	70	0.0350	
2	80	0.0282	
3	90	0.0254	
4	100	0.0247	
5	126	0.0183	

TABLE 4 ENGINE OIL

Series A: Loads of 20 to 174 Lb. per Sq. In.; Diameter of Bearing 2⅝ In., Length 1½ In.; Tests of This Oil were for the Purpose of Comparing Oil with Grease under the Same Conditions

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Load on Bearing 20 Lb. per Sq. In.; Surface Speed of Journal 825 Ft. per Min.			
1	79	0.0630	Room temperature 79 deg.
2	82	0.0541	Motor was reversed at each observation
3	87	0.0470	
4	90	0.0455	
5	92	0.0435	
6	96	0.0405	
7	100	0.0399	
8	105	0.0362	
9	108	0.0344	
10	109	0.0389	
11	110	0.0380	
12	111	0.0330	
13	111	0.0330	
14	111	0.0330	
Load on Bearing 46 Lb. per Sq. In.; Surface Speed of Journal 825 Ft. per Min.			
1	88	0.0292	Room temperature 90 deg.
2	93	0.0236	Motor was reversed at each observation
3	98	0.0222	
4	101	0.0206	
5	104	0.0200	
6	106	0.0198	
7	108	0.0186	
8	109	0.0186	
9	111	0.0182	
10	112	0.0190	
11	114	0.0176	
12	115	0.0178	
13	116	0.0178	
14	117	0.0178	
15	118	0.0176	
16	...	0.0178	
17	119	0.0176	
18	120	0.0176	
Load on the Bearing 71.5 Lb. per Sq. In.; Surface Speed of Journal 825 Ft. per Min.			
1	81	0.0234	Motor was reversed at each observation.
2	86	0.0209	
3	92	0.0173	
4	96	0.0170	
5	102	0.0170	
6	107	0.0146	
7	109	0.0142	
8	110	0.0142	
9	111	0.0135	
10	112	0.0135	
11	112	0.0130	
12	113	0.0130	
13	113	0.0136	
14	115	0.0136	
15	115	0.0137	
16	116	0.0129	

TABLE 4—(*Continued*)

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Load on Bearing 97 Lb. per Sq. In.; Surface Speed of Journal 690 to 825 Ft. per Min.			
1	89	0.0138	Room temperature 90 deg.
2	96	0.0137	Motor was reversed at each observation.
3	101	0.0133	
4	107	0.0129	
5	107	0.0123	
6	111	0.0121	
7	114	0.0119	
8	116	0.0120	
9	118	0.0120	
10	119	0.0120	
11	120	0.0120	
12	122	0.0119	
13	123	0.0119	
14	124	0.0117	
15	...	0.0121	
16	127	0.0117	
17	127	0.0105	
18	128	0.0105	
19	128	0.0105	
20	129	0.0104	
21	129	0.0105	
Load on Bearing 122 Lb. per Sq. In.; Surface Speed of Journal 825 Ft. per Min.			
1	75	0.0196	Room temperature 77 deg.
2	83	0.0144	
3	89	0.0136	
4	94	0.0099	
5	98	0.0126	Motor reversed
6	102	0.0113	
7	104	0.0108	
8	...	0.0113	Motor reversed
9	106	0.0107	
10	108	0.0099	
11	110	0.0099	
12	...	0.0095	Motor reversed
13	111	0.0092	
14	...	0.0099	
15	113	0.0107	
16	...	0.0077	Motor reversed
17	115	0.0101	

TABLE 4—(*Continued*)

Number	Bearing Temperature, Deg. Fahr.	Coefficient of Friction	Remarks
Same load and speed; second test			
1	81	0.0151	
2	87	0.0143	Motor reversed
3	95	0.0131	Motor reversed
4	101	0.0114	Motor reversed
5	104	0.0109	Motor reversed
6	106	0.0109	
7	109	0.0110	Motor reversed
8	111	0.0108	Motor reversed
9	113	0.0108	
10	115	0.0109	Motor reversed
11	116	0.0107	Motor reversed
12	118	0.0106	
13	119	0.0106	Motor reversed
14	121	0.0095	
15	123	0.0091	Motor reversed
16	124	0.0098	Motor reversed
17	124	0.0098	
18	...	0.0096	
Load on Bearing 148 Lb. per Sq. In.; Surface Speed of Journal 825 Ft. per Min.			
1	75	0.0172	Room temperature 76 deg.
2	82	0.0142	Motor was reversed at each observation
3	90	0.0120	
4	96	0.0108	
5	101	0.0108	
6	105	0.0113	
7	110	0.0121	
8	113	0.0105	
9	114	0.0094	
10	116	0.0083	
11	118	0.0082	
12	120	0.0082	
Load on Bearing 174 Lb. per Sq. In.; Surface Speed of Journal 755 to 825 Ft. per Min.			
1	84	0.0134	Room temperature 80 deg.
2	91	0.0109	Motor was reversed at each observation
3	96	0.0100	
4	100	0.0101	
5	106	0.0101	
6	111	0.0098	
7	114	0.0082	
8	116	0.0061	
9	117	0.0060	
10	119	0.0061	
11	120	0.0060	
12	121	0.0059	

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Through the collaboration of the Library Committee of the United Engineering Societies, the range of papers available for the Foreign Review is gradually being extended so as to cover all the most important non-English publications. In the present issue, for instance, several articles are abstracted from Swedish and Russian periodicals. It is the intention of the Editor to give brief abstracts of articles even of secondary importance from these publications, because otherwise they would most likely remain entirely unknown to the engineering profession, the publications containing them, as far as the Editor is aware, not being generally covered by engineering indexes.

THIS MONTH'S ARTICLES

An abstract of the article by Kaplan on the two dimensional water turbine theory is given: a runner constructed in accordance with this theory is said to have shown an efficiency of 80 per cent. Gas power men will be interested in the description of the Marischka combined gas producer and boiler, with its arrangement for fully utilizing the heat of the gases. In the same section is described the slide valve gear of the Dubois-Rousseau engine, which is of interest owing to its apparent simplicity; another engine, described in the Russian technical paper *Dvigatel*, represents an attempt to construct a Diesel engine without any fuel atomizing devices, and moreover requiring no lubrication, part of the fuel used acting as a lubricant, and then burning on a special cycle of its own. Data of the tests on Diesel-electric locomotives on the Swedish state railroads are also given, the conditions of operation of the locomotives under tests corresponding somewhat to those prevailing in the suburban traffic of the larger American cities. In the section Mechanics attention is called to the article describing the method for the experimental determination of the moment of inertia of runners, permitting one to judge, to a certain extent, of the homogeneity of the materials used, a question sometimes of great importance in rotors of large dimensions and subject to considerable mechanical stresses. In this connection may also be mentioned an article on alloys for use in high-pressure steam

turbines, giving data of the work done in this respect by German government laboratories and manufacturers. R. Slaby's brief article indicates a simple way of constructing a differential curve to any given one, without having to determine tangents, and using the simplest graphical operations and tools. Owing to lack of space, the part of the article in which Mr. Slaby shows mathematically that his curve is not an approximation, but a real differential curve, had to be omitted. The brief notice by Professor Timiriazeff on the internal friction of rarefied gases, though classed under Mechanics, may also be of interest to the gas and gasolene engine designers, as bearing on the carbureter and gas mixer construction.

The Schuch rivetting indicator is briefly described: it shows to the workman how long the pressure on the rivet is kept, and at the same time makes automatically records valuable both for the determination of the quality of the job done, and for the accounting and rate setting departments.

In the section Steam Engineering is described the Breguet Ejectair, a new and apparently efficient apparatus for producing vacuum in condensers of steam engines. The principle of the apparatus is not new, but the design has several interesting features. The Lomshakoff furnace is illustrated, and mention is made that in tests with it difficulty was experienced owing to lack of apparatus, showing the efficiency of furnaces with undergrate draft, as well as the general usefulness of using compressed air for undergrate draft. The next abstract gives data of tests with the Marcotty smoke consuming apparatus on locomotives, proving the economy of installing such a device.

Several articles on the elastic limits of alloys, distribution of stresses in notched bars under tension, expansion of nickel steel at temperatures up to 300 deg. cent. (572 deg. fahr.), sound conductivity of building materials and walls, etc., are also given. It is proposed to start a new section devoted to abstracts of articles on railroad matters in one of the early issues.

Hydraulics

Two-Dimensional Turbine Theory, with a Consideration of Water Friction, and Its Application to the Design of Blades (*Die zweidimensionale Turbinentheorie mit Berücksichtigung der Wasserreibung und ihre Anwendung und Ergebnisse bei Schaufelkonstruktionen*, V. Kaplan. *Zeits. für das gesamte Turbinenwesen. Serial article.*

The main difficulty of a theoretical treatment of flow processes lies in an appropriate consideration of internal liquid friction and wall friction. The author has previously established that, owing to the viscosity of the fluid,

in each fluid flow there is a tendency for the establishment of a state of resistance characterized by the fact that in a section normal to the direction of flow all units (by weight) of the flowing liquid contain the same amount of energy. The author calls a flow in this state of resistance "free flow." The wall friction in this case need not be considered. Should a working flow, i.e. one that besides effecting its own motion delivers work to the outside, be "free," a uniform amount of energy must be taken off from every section of the flow. When, however, no work is delivered outwards, the flowing system is at rest, and the author calls it a "no-work flow." The purely analytical investigation of a flow is especially difficult when the shape of the passage is difficult to express analytically, as is usually the case with the water passages in turbine runners. Whenever available, graphical results are to be preferred on account of their being easier to comprehend and simpler in expression. For a free flow pressure and velocity at any particular spot in all practical cases may be expressed in two-dimensional flow images, provided the wall friction is neglected and

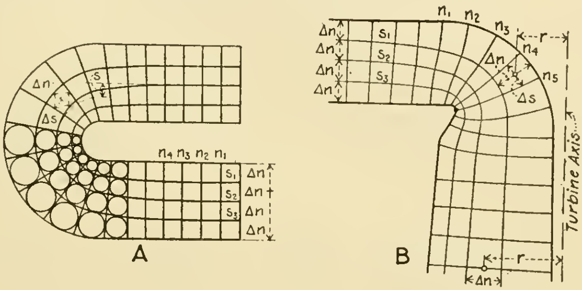


Fig. 1 Flow Images, Water Turbine Wheel

certain conditions simplified. As an example may be shown (Fig. 1A) the flow image of a U-shaped passage. The total flow is divided into partial flows of equal rate, and, since the energy contents in all the partial flows in a cross-section normal to the direction of flow have been shown to be constantly equal to one another, along such a section the relation must exist of $\frac{\Delta n}{\Delta S} = \text{const.}$ It is convenient to select $\frac{\Delta n}{\Delta S} = 1$, in which case the construction may be facilitated by the little circles shown in the Fig. 1A. In the flow image the stream lines s_1, s_2, s_3 . . . . indicate the limits of partial streams of equal water delivery per second, while the lines normal to them indicate sections of equal energy content ("lines of level"). For a free flow in a hollow body of revolution, such as occurs in guide wheels and runners of a Francis turbine, Fig. 1B, there is a further condition that $r.\frac{\Delta n}{\Delta S}$ must be constant. In accordance with this flow image a blade with no wall friction may be constructed, as set full in the article (for practical purposes a correction for wall friction must be made, however).

The following has been found with respect to flow accompanied by friction: If c_1 is the velocity of flow in a canal with frictionless walls, it is reduced to $c = \frac{c_1}{k_t}$ under the action of bottom friction, and to $c = \frac{c_1}{k_s}$ by the side wall friction. Since, however, the bottom and side wall frictions act simultaneously, strictly speaking they may be represented only in three dimensions. The coefficient k depends on the roughness of the surfaces and their distance from one another, and varies from infinity for distance zero to 1 for distance ∞. Experiments have shown however that the value 1 is actually reached at comparatively small distance between the walls (about 40 mm, or 1.6 in.). Care must be taken properly to consider the action of strong curvatures; thus, in Fig. 1B with free flow the maximum velocity of flow appears to be at A, while the actual velocity at that point is 0. The design of turbine runners with respect to wall friction has naturally to depend on certain assumptions subject to subsequent correction, due to the fact that the resistances are affected by the type of body design which has still to be found. The design fully described by the author is characterized by the fact that the lines of flow are pressed somewhat close to the middle line of flow, due again to the fact that the velocities nearer the passage walls are made somewhat smaller.

To test the correctness of the above theory, a runner 100 mm (4 in.) in diameter has been constructed, and compared with one designed in accordance with the usual unidimensional theory. The efficiencies found were 80 and 73 per cent in favor of the new type.

Prime Movers in Waterworks and their Influence on the Economic Diameter of Pressure Piping (*Über Antriebsarten von Pumpwerken und deren Einfluss auf den wirtschaftlichen Durchmesser von Druckrohrleitungen*, E. Rutsatz. *Journal für Gasbeleuchtung*, vol. 56, no. 19, p. 444, 8 pp., 6 figs. *c*). Discussion of comparative advantages of steam and internal-combustion engines and electric motors as prime-movers for water works. Nothing definite is said as to the relation between the kind of prime-mover and piping diameter.

Experiments on Pressure Variation in the Piping of a Francis Turbine Plant with Change of Load (*Versuche über die Druckänderungen in der Rohrleitung einer Francis-Turbinenanlage bei Belastungsänderungen*, A. Watzinger and O. Nissen. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 134, 1913, p. 27, 18 pp., 34 figs. *e*). Experimental data, not suitable for abstracting: regulation phenomena and pressure variations with change of load investigated.

Rational Construction of Concrete Suction Pipes (*Construction rationelle des tuyaux d'aspiration en Béton*, Th. Kach. *La Houille blanche*, vol. 12, no. 4, p. 116, 2 pp., 3 figs. *t*). Brief exposition of the Dubs process for the determination of the shape of suction pipe in water turbine installations involving the least losses through residual velocity of the water (this is especially important with low heads, where the relative amount of power lost on this account is particularly large).

Internal Combustion Engines

Engines at the General Agricultural Exhibition (*Les machines au Concours General Agricole*, H. Pillaud. *La Technique moderne*, vol. 6, no.

10, p. 387. Serial article, *d*). Among other things, the article describes internal-combustion engines shown at the French General Agricultural Exhibition. The Dubois-Rousseau factory has shown a slide-valve engine of great simplicity, with an ordinary cylinder, and characterized only by a special valve gear located at the top of the cylinder normally to its axis. This valve gear is tube-shaped, with a section in the middle cut out so as to form a longitudinal port opening a communication with the cylinder. The two extremities have been slit along the generating line in a manner such that the cylinder might, under the action of pressure, open slightly and so make a better contact with the wall enclosing it. In its different positions, the valve gear may be in communication either with the inside of the cylinder, or with the admission or exhaust pipes; it can oscillate under the action of a single connecting rod driven from a cam running

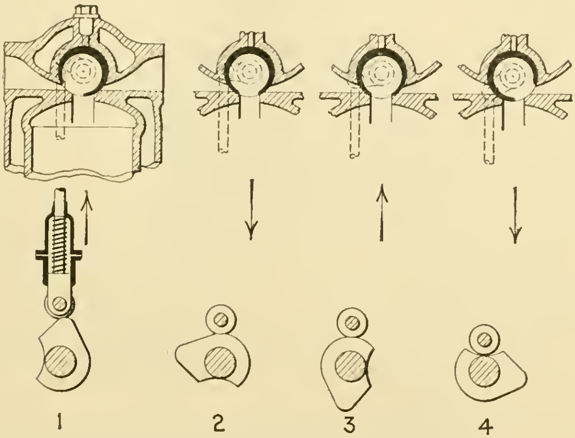


Fig. 2 Dubois-Rousseau Slide Valve Gear

at half the speed of the engine. Fig. 2 shows the position of the valve gear during the entire cycle. The valve gear is stationary during the second and third stroke, and it is then that its elasticity is of importance in permitting it to make a tight contact with the enclosing walls, and thus prevent leaks. The same valve gear may be applied also to multicylinder engines.

Concerning Crude Oil Engines (*Über Rohölmotoren*, F. Weinreb. *Elektrotechnik und Maschinenbau*, vol 31, no. 21, p. 444, May 25, 1913. 6 pp., 11 figs. *cdh*). A general article on the introduction and use of internal-combustion engines, and their economy. The paper contains numerous data showing that, in Germany and Russia, it has been found that for central station work the Diesel engine proved to be not only more reliable than the steam turbine, but also more economical. The greater reliability of the Diesel engine lies mainly in the fact that it permits a larger reserve storage of fuel than steam plants, and makes the plant better protected against interruptions of service caused by tie-ups in transportation or strikes.

Diesel-Electric Motor Cars (*Diesel-elektriske motorvogne, Elektroteknisk Tidsskrift*, vol. 26, no. 13, p. 99, May 5, 1913, 3 pp., 3 figs. *d*). In *The Journal* (May 1913, p. 888-889) reference was made to the Diesel-electric locomotives installed lately on the Swedish railroads. The present article describes them in detail. The locomotives are designed to run at 60 km (37.2 miles) maximum speed per hour, and take care of two trailers, of total weight 30 tons (33 short tons) besides that of passengers. The power equipment consists of a 6-cylinder, 75-effective-horsepower Diesel engine, running at 700 r.p.m., and a direct-connected 50 kw., 440 volt, direct current generator, supplying current to two 30-h.p. motors. The Diesel engine is of the four-stroke cycle type, with six working and one pump cylinder supplying compressed air for starting the engine and fuel injection. The air for the brakes is supplied from a separate little pump. The fuel tank is designed to hold fuel for a run of 1200 km (745 miles) with two trailers, and 1800 km (1120 miles) without the trailers.

The locomotive was tested in May 1912 in runs between the stations Enköping and Heby, distance 37 km (23 miles), containing grades as stiff as 11 promill, and minimum radii of curvature 300 mm (984 ft.). Between these two stations there are five intermediate stations at which stops were always made. The runs were made either with the motor car alone, or with trailers, passenger or goods cars, the weight of the trailers not exceeding 45 tons (49.5 short tons). The following data as to fuel (crude oil) consumption are given:

a Motor car alone, weight of train 26.5 tons (29.150 short tons), speed 40 to 45 km (24.8 to 27.9 miles) per hour; fuel consumption per run 8.8 kg (18.4 lb.), per train-kilometer 0.238 kg (0.842 lb. per train-mile).

b Motor car and trailer (passenger car), weight of train 40 tons (44 short tons), speed about 40 km (24.8 miles) per hour; fuel consumption per run 11.25 kg (24.75 lb.), per train-kilometer 0.304 kg (1.07 lb. per train-mile).

c Motor car, one passenger car, and one or two goods cars, train weight about 60 tons, speed 35 km (21.7 miles) per hour; fuel consumption per run 12.6 kg (27.72 lb.), per train-kilometer 0.342 kg (1.21 lb. per train mile).

Utilization of Blast Furnace Gases in Gas Engines (*Sur l'utilisation des gaz de hauts fourneaux dans le moteurs à gaz*, Ch. Reignier, *Société industrielle de L'Est*, no. 109, p. 21, April 1913. 10 pp., 2 figs. *dgh*). General, partly historical paper on the use of blast furnace gases in gas engines. The author asserts that a kw-hr. can be produced from blast furnace gases at two centimes (say $0.004), this figure being considered rather as a maximum for a well appointed plant.

Gas Producers for Power Gas (*Über Gaserzeuger für Kraftgas*, Gwosdz. *Oel- und Gasmaschine*, vol. 13, no. 2. Serial. *d*). Semi-annual account of progress in the field of gas producer engineering. In Fig. 3 is shown a *combined revolving grate producer and steam boiler* designed by the chief engineer of the Vienna Municipal Gas Works Marischka. The shaft of this producer, to its full length, is made into a steam boiler, divided into two parts with a large number of water tubes between, in order to utilize the heat contained in the gases leaving the producer. In addition the larger part of the boiler is provided with a jacket, which forces the gases to flow

along the surface of the boiler during a considerable part of their way out. By this arrangement it has proved possible to reduce the temperature of the gases leaving the producer to 220 deg. cent. (428 deg. fahr.), while the steam in the boiler is brought to six atmospheres gage pressure. Only part of this steam is required for the gas producer itself; the rest may be used for general requirements. The chief value of this producer lies in the fact that it takes care of cooling the gases down to near the temperature at which they can be conveniently handled in the gas engine, and at the same time utilizes their excess of heat. This is not the first attempt to combine a gas producer with a boiler, but it is only the revolving grate that made such a construction commercially practicable, owing to the large

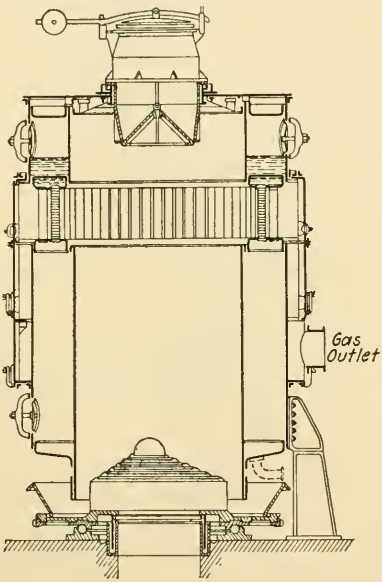


FIG. 3 MARISCHKA COMBINED REVOLVING GRATE PRODUCER AND STEAM BOILER

amount of fuel handled, and correspondingly large amount of heat developed per unit of shaft cross-section. Attempts to use the same construction in gas producers with by-product recovery do not appear to have been successful, owing to settling of tar in the boiler jacket.

DELIVERY OF FUEL INTO THE CYLINDERS OF INTERNAL-COMBUSTION ENGINES FROM UNDER THE PISTON RINGS *(O podache garyoochera v zylindry drigateley vnootrennyera sgaraniya ispod porshnevykh kaletz*, V. Poksziszevski. *Drigatel*, vol. 7, nos. 3 and 7, pp. 37 and 105. 7 pp., 6 figs. *d*). The author considers mainly engines of the Diesel type, and finds the following imperfections in their design: *(a)* the atomizer is a very delicate device, not easily adjustable, and apt to get out of adjustment with change in the consistency of fuel; further, it requires a high air compression, especially

when the engine is burning oil residues (mazout); the air compressor and atomizer are the two weak elements in the Diesel engine operation; (*b*) lubricating oil is a heavy expense, owing to the high cost of oil suitable for internal-combustion engines; the author states that, at the prices of oil and fuel prevailing in Russia, the lubrication costs from 13 to 17 per cent of the cost of fuel. His idea is therefore to construct an engine that would work without fuel atomizer devices, and provide its own lubrication. This is to be done in the following manner (only a brief description showing the principle of the new design is given here: the engine has not yet been built, and therefore it is not considered worth while to go extensively into details): A ring *C* (Fig. 4) shaped as shown, of some soft and elastic material, such as soft iron, bronze, etc., is provided on the piston, its diameter being about 0.02 in. less than that of the cylinder in which the piston moves. The fuel (naphtha or oil residues) passes from a tank (not shown) where it is periodically under pressure, through pipes *i* and *b* into the ring shaped space *a* under the ring *C*. The cycle of the engine is then as follows:

a forward stroke: working, combustion.

b backward stroke: exhaust of the products of combustion, accompanied, if desired, by air scavenging.

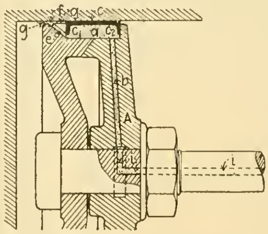


Fig. 4 Internal Combustion Engine Piston with Fuel Delivery through the Piston Rings

c forward stroke; air admission and exhaust valves are both closed; a vacuum is formed in the cylinder; at the same time the fuel in the space *a* under the ring *C* is set under pressure from the tank; as a result, while the piston moves forward, the fuel is forced out through the duct *e* into the passage *f*, whence it goes to cover by a thin layer the cylinder walls; the comparatively high temperature of the cylinder walls, together with the partial vacuum in the cylinder, combine in producing the evaporation of a large part of the fuel thus spread on the walls of the cylinder; the heaviest constituents of the naphtha will however not evaporate, and it is they that form a layer taking care of the cylinder lubrication. At the end of this stroke air is admitted into the cylinder, either direct from the atmosphere, or under some compression.

d backward stroke: the mixture of air and naphtha vapor is compressed and, when near the dead point, ignited, either artifically, or through its own compression.

$e =$ (*a*) forward stroke, working, combustion; the mixture of air and naphtha vapor burn on the Otto cycle, while the naphtha which stayed on the cylinder walls, and had no time or chance to evaporate, burns additionally, and thermally superimposes itself on the Otto cycle. The operation of the engine is therefore between the Otto and Diesel cycles.

There is of course a certain possibility of uncombustible residues of the naphtha used settling on the cylinder walls; as advantages of the described construction are pointed out by the author: reduction in the size and weight of the piston, and reduction in the consumption of cooling water, due to partial cooling produced by the spreading and evaporation of naphtha.

Machine Shop

Concerning the Basis for Determining the Power Consumption in Press Forging (*Über die Grundlagen zur Ermittlung des Arbeitsbedarfes beim Schmieden unter der Presse*, Fr. Riedel. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 22, p. 845, May 31, 1913. 6½ pp., 21 figs. *e*). The scope of the article is considerably broader than its title would indicate. The author points out that, while the power consumption in press forging may be determined, too little is known as yet to establish a law showing the relation between the amount of power consumed and the change of form produced thereby. He shows that such a relation is materially affected by the formation, when plastic bodies are compressed, of slip cones (*Rutschkegel*), and how actual data as to the strength of wrought iron at various temperatures may be obtained by means of an electric furnace. He discusses at some length the equations regulating cooling of iron by conduction and radiation.

Schuch Riveting Indicator (*Schuchscher Nietkontroller*, G. Hilliger. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 22, p. 263, May 30, 1913. 2½ pp., 5 figs. *d*). There has been no way to determine the quality of a riveting job besides knocking of some rivet heads, and inspecting the fractures. In the riveting process itself there have been established practically and experimentally certain lengths of time for the pressure to be applied on the rivet head, but there was no certainty that these were actually adhered to; rather the contrary is to be assumed to be more generally the case: the workman's attention is so much taken up by handling his tools that, with no stop watch at his command, he is hardly likely to be able to time his operation to within the seconds necessary to make a really good job of riveting. The Schuch riveting indicator is intended to obviate all these difficulties. It consists of two parts: The first records and indicates the pressure applied, and time during which it is applied, while the second simply draws a time line. When the riveting is started, the pressure-time line gradually rises until the full pressure is applied; the workman has then conveniently located in front of him a seconds indicator which permits him to keep the pressure for just as long as is wanted: The second line indicates the time of day when each rivet was made, and thus permits keeping account of the amount and steadiness of work done, giving valuable data for making up the pay check. The apparatus works

automatically, and appears to be of simple construction. No detailed description is here given because the illustrations in the original are somewhat blurred, and would be difficult to reproduce.

Measuring Instruments

Safety Device for Use in Connection with the Junkers Recording Calorimeter (*Eine Sicherungsvorrichtung für das Junkers'sche Registrierkalorimeter*, W. Allner. *Journal für Gasbeleuchtung*, vol. 56, no. 19. p. 438, 3 pp., 4 figs. *d*). One of the conditions of correct working of the Junkers recording calorimeter is that the gas and water (the latter used for taking up the heat of combustion of the gas) should flow to the calorimeter uninterruptedly. The device described consists of an electrically operated cock which shuts off the gas admission to the calorimeter whenever there occurs a disturbance in the flow of either gas or water, and at the same time sounds an alarm clock. This device prevents both the possibility of overheating the calorimeter and formation of an explosive mixture inside it. The device is said to have been in use for nearly a year and given satisfaction.

Mechanics

Experimental Determination of the Moment of Inertia of Runners (*Experimentelle Bestimmung der Trägheitsmomente von Laufrädern*, A. Lechner. *Dinglers polytechnisches Journal*, vol. 328, no. 22, p. 337, May 31, 1913. 2½ pp., 2 figs. *e*). The moment of inertia of a body has been hitherto determined by the method of oscillations, or from the inertia period, or by means of the Atwood machine. The author proposes a new method based on the following principle. When a pair of wheels rolls down an inclined plane in a straight line, a condition of pure rolling is that, first, there is friction of adhesion, or that $(R) \leq N.f$, and second that $v - r \quad \omega = 0$, where v is the velocity of the center of gravity of the system, ω angular velocity, r radius of the wheel, N normal pressure, and f coefficient of friction. If further, T be the moment of inertia, m mass of the system ψ angle of inclination of the plane to the horizontal, then:

$$m\frac{dx}{dt} = mg \sin \varphi - R \qquad [1]$$

and

$$0 = N - mg \cos \varphi \qquad [2]$$

$$T\frac{d\omega}{dt} = R \, . \, r \qquad [3]$$

and since $v = r\omega$, it follows that

$$\frac{dv}{dl} = g \sin \varphi \frac{mr^2}{T + mr^2} \qquad [4]$$

The acceleration $\frac{dv}{dl}$ may be expressed by the length of the path s and respective time t, in which case [4] becomes

$$T = mr^2\left(g\frac{\sin \varphi}{2\,s} \cdot t^2 - 1\right) \qquad [5]$$

from which T may be determined. The author shows how he has proved by the use of a supplementary inequality that he has been dealing with pure rolling.

Fig. 5A shows the general arrangement of the testing apparatus. The plane AB is horizontal; the angle φ determined from the values of AC and AE. On the axis of the body subject to rotation is fixed a needle and the body itself is placed in its initial position at E in such a manner that the point of the needle is just covered by the vertically hanging thread; the body is kept in this position by a powerful electromagnet. A stop-watch is set into action at the moment when the current is interrupted in the electromagnet circuit at W, and is stopped when the needle touches the other vertical thread GD. The measurement of time is of the greatest importance in this process. In order to establish the moment of the passage of the needle by the thread GD, a telescope L was placed in front of the thread on which a ray of light was projected. In other tests the apparatus was arranged so that the observer could see only the points E and D. Several other methods were tried, but it was found that the more elaborate processes gave practically the same results as direct observation. Full data of the tests are given. The values obtained for the wheel tested varied

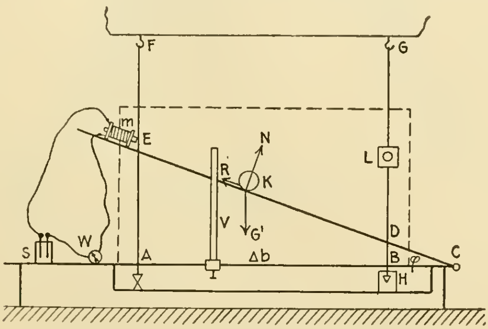


Fig. 5 Arrangement of Apparatus for Determining the Moment of Inertia of Runners

between 418 and 461 g cm^5, while the calculated value for the wheel under test was 436 g cm^5. It must be borne in mind, however, that the calculated value is based on the assumption of perfectly uniform distribution of matter in the structure, and no allowance is made for possible lack of homogeneity of the material, blowholes, etc. The method might be considerably improved by introducing automatic time recording, in which case it could be used for large wheels.

Approximation Method for the Investigation of Stability of Elastic Systems (*Näherungsmethode zur Untersuchung der Stabilität elastischer Systeme* S. Timoschenko. *Kiewer Univ.-Nachr.*, 52, no. 7, p. 25, 1912, through *Beiblätter zu den Annalen der Physik*, vol. 37, no. 9, p. 579, 1913. *et*). When one or two dimensions of an elastic body are very small, small deformations may produce large changes of form. Then, starting from a "critical" load, there may be several equilibria with a single system of forces, and the one corresponding to a minimum of potential energy is a stable one. With the critical load the work of external forces T required for displacement of the system from its equilibrium is equal to the change in the internal energy of the elastic system V, and an approximate

determination of the critical load may be effected by determining, with due restrictions as to the limiting conditions, some equilibrium of the values of T and V. This method gives somewhat high values for the critical load, and several determinations have to be made before the degree of approximation can be estimated. The original article shows how this method is applied to technical problems some of which have not yet been solved owing to the difficulty of integrations.

A Simple Method for Constructing a Differential Curve (*Ein einfaches Verfahren zur Bildung von Differentialkurven*, R. Slaby. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 21, p. 821. 2 pp. 3 figs. *p*). It is often necessary to construct a curve that would show the differential of another curve, e.g., a velocity or acceleration curve from a time-path curve. The author recommends the following simple method of constructing such curves. The original curve a (Fig. 6) to which a differential curve has to be constructed, is displaced, parallel to the axis of abscissae, through some small distance u, and the difference in ordinates between the original and derived curve b plotted as a curve: *this curve is the desired differential curve.* Since, however, it is displaced in position from the original curve, it may be shifted through $u/2$ towards the origin, in order to bring it into complete correspondence with the curve a. The author proceeds to prove mathematically that the curve of differentials so obtained is not an approximation, but practically an exact curve of differentials. This part of the article is omitted owing to lack of space.

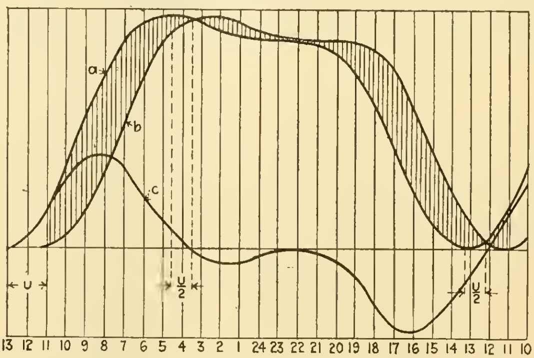


Fig. 6 Differential Curve Construction

Internal Friction of Rarefied Gases (*Über die innere Reibung verdünnter Gase*, A. Timiriazeff. *Annalen der Physik*, ser. 4, vol. 40, no. 5, p. 971, 1913. 20 pp., 10 figs. *etA*). Only the conclusions of this interesting article can be given here. The author describes a process for the determination of internal friction in rarefied gases. In the theoretical part of his investigation he follows mainly the Maxwell-Bolzmann method and determines the variation of quantity of motion as a function of pressure. He finds that: (a) as has been established by previous experimenters, the sliding of gas particles along the surface of a solid body in contact with the gas is inversely proportional to the density of the gas,

and therefore can be observed only in the case of gases of comparatively low density; in this case, however, the magnitude of the sliding is $a_0/p = c_0\lambda$, and is therefore directly proportional to λ, average free length of the path, and inversely proportional to the pressure p. (*b*) The coefficient of sliding a_0 is related to the coefficient of sudden change of temperature γp (introduced by Smoluchowski) in accordance with the following simple equation: $a_0 = \frac{8}{15}\gamma p$. (*c*) The coefficient of sliding a_0 has been determined by measuring the sudden changes of temperature, and the theoretical curve G of variation of quantity of motion was

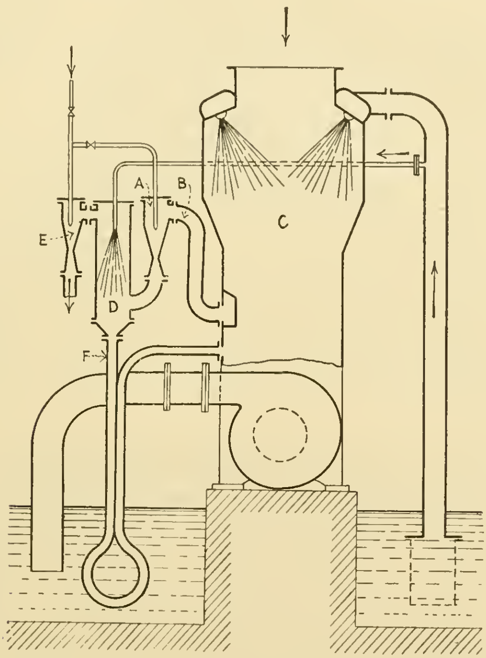


Fig. 7 Breguet Ejectair

plotted as a function of log p. Experiments with air and carbon dioxide have confirmed the correctness of the above. (*d*) The curve $G = f$ (log p) has an inflection point corresponding to pressure p_1 inversely proportional to the thickness of the gas layer d. The above does not apply to cases of very high rarefication.

Steam Engineering

Breguet Ejectair (*L'Ejectair Breguet*, H. Eric. *Revue industrielle*, vol. 44, no. 2085/20, p. 265, May 17, 1913. 2 pp., 4 figs. *d*). Description of a new apparatus for producing vacuum in condensers of steam engines. Neither the principle of the apparatus nor its construction are really new, but the designer of the present device, Maurice Delaporte, of the Breguet Works, of Paris, France, was the first to construct one that would work

economically. The distinctive feature of the Breguet Ejectair is the use of two ejectors in series (Fig. 7). The first one *A* takes steam, by the pipe *B* from the condenser *C* in which a vacuum has to be produced, and drives the mixture of air and steam into an auxiliary condenser *D*, where the air is picked up by the second steam ejector *E*, while the water collecting at the bottom of the auxiliary condenser *D* is directed, by the pipe *F* (notice its shape) to the water pump of the main condenser. The pipe *F* is shaped as shown in order to make it answer its three purposes: to permit maintenance of a difference of pressure between the two condensers, allow water to flow, and prevent the flow of air. The only pump with moving parts in this apparatus therefore takes care only of water, and therefore an ordinary centrifugal pump of simple and rugged construction may be used. The name ejectair has been given to the combination of two ejectors in series and auxiliary condenser. This device was further improved by providing for an injection of cold water into the pipe *B* by which the ejector *A* takes the gaseous mixture from the main condenser. By this means part of the vapor in the mixture is condensed, and its air contents increased, so that, for the same volume handled by the ejectair, the actual volume of air extracted from the condenser becomes considerably higher. The Breguet apparatus can be easily adapted for use with surface condensers. All the steam used by the ejectors is exhausted into the feedwater tank; the apparatus is started simply by admitting steam to the ejectors, no priming being necessary; practically no attendance is required since even considerable variations of pressure do not affect the vacuum produced. (From paper read before the French Society of Civil Engineers.)

Influence of Air Supply on Smoking Fires (*Einfluss der Luftzuführung bei qualmenden Feuern*, de Grahl. *Zeitschrift für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 21, p. 251, May 23, 1913. 2½ pp., 2 figs. *cp*). The author describes tests made to determine whether the cutting out of smoke consuming apparatus on locomotives and trailers affects the steam production and efficiency of the boiler, and if so, how. A Marcotty smoke consumer was used, the gases being collected shortly after new fuel had been thrown in in glass balloons, and subsequently tested in the laboratory. This proved to be more convenient than the usual tests on the spot with an Orsat apparatus inasmuch as it permitted the determination, in addition to (CO_2) and (O_2), of the contents of carbon monoxide, hydrogen and methane (CH_4). The author points out that in many tests the efficiency of a boiler plant is determined from the steam making capacities, without considering that, with a high level of water in the boiler, some of the water is carried away by the steam, and the result is apt to become misleading. Unless the water level is kept low, the results as to fuel utilization may be quite wrong, and differ materially from values obtained with a different water level. In addition to the usual determination in tests of efficiency of smoke consuming apparatus, the unburned gas particle should be determined as they affect the heat losses. Table 1 shows the difference of operation with the smoke consumer in action and cut off, and proves the importance of heat losses due to escape of CO, H_2 and CH_4 through smoke emission of the fire after fresh stoking, losses which

are to a large extent eliminated by the application of the smoke consuming device, i.e., use of overgrate blast. Attention is also called to the temperatures of flue gases, from which very misleading conclusions could easily be drawn. In fact, in test no. 1, with the smoke consumer cut out, the flue gas temperature is 305 deg. cent. (581 deg. fahr.), with the Marcotty apparatus in action 420 deg. cent. (788 deg. fahr.): the lower temperature in the first case is, however, due to incomplete combustion, and canot be used as an argument for the presence of higher efficiency.

On the whole the author found that, with the smoke consuming device cut out, the smoke stack losses were 10.41 per cent, and the losses through incomplete combustion (no attention was paid to carbon particles in the flue gases) 18.71 per cent; with the Marcotty device in operation, the respective losses were 19.85 and 0.47 per cent, thus giving a total distinctly

TABLE 1 SMOKE CONSUMER TESTS

Time	CO_2	O_2	CO	H_2	CH_4	N_2
Marcotty Smoke Consumer Cut Out						
1.26	13.65	2.00	2.81	1.31	0.48	79.75
1.26¾	13.20	1.35	5.13	1.90	0.57	77.85
1.27½	13.65	1.35	3.68	1.61	0.40	79.31
1.28¼	14.60	2.20	2.77	0.46	0.22	79.75
Marcotty Smoke Consumer in Operation						
12.25½	12.20	5.50	0.22	0.07	0.11	81.90
12.26¼	12.70	6.00	....	....	....	81.30
12.27	15.00	4.00	....	....	....	81.00
12.27¾	13.00	6.50	....	....	....	80.50
12.29	12.00	7.50	....	....	....	80.50

in favor of the smoke consumer operation. As the period after stoking increases, the two sets of figures naturally approach one another. The article contains a description of the author's tests which cannot be more fully reported here owing to lack of space.

This table shows that while the smokestack losses are larger when the smoke consumer is used, the losses through incomplete combustion of gases are in that case so small as to make the final result materially in favor of the use of the smoke consumer. This is further illustrated in the original article by diagrams. The author states that firemen are usually against using visible air admission, because it may be easily abused and thus produce fall of vacuum, decrease of steam production, and increased fuel consumption. It is therefore advisable to install, in connection with smoke consuming apparatus, devices for automatically ("invisibly to the fireman," as the author expresses it) regulating the air admission, and

at the same provide means for restoring the vacuum produced by supplementary air admission. In locomotives an auxiliary air blower should be provided which would automatically begin to act as soon as the steam was shut off, so as to provide the air necessary for a proper consumption of coal. All the devices concerned with smokeless coal burning on the locomotive must be automatic, since the fireman's work is so strenuous as to leave him no time for their proper handling.

The Modern Problems of the Furnace Room and Their Solution (*Sovremeniya zadachi kachegarki i ikh reshenye*, K. I. Plamenevski. *Zapiski of the Russian Imperial Technical Society* (in Russian), vol. 47, no. 3, p. 67, March 1913, serial, not finished. *ed*). General discussion and comparative description of various types of *boiler furnaces*, among others

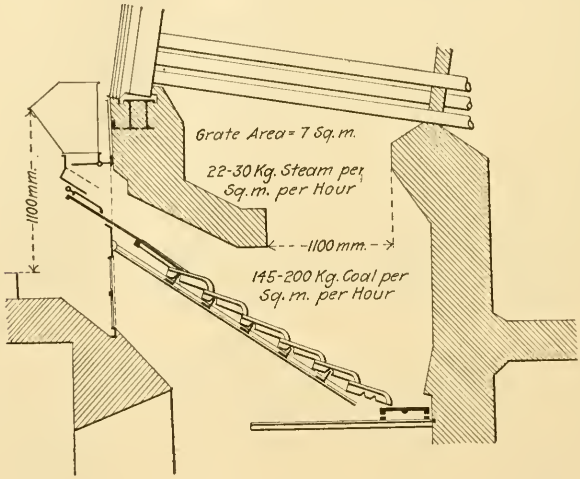


Fig. 8 Lomshakoff Furnace

that of the *Lomshakoff furnace*, tested at the Nevsky shipbuilding works in St. Petersburg, Russia. It is of the inclined grate type (Fig. 8), with arches directing the flow of gases over the incandescent fuel, these gases being conducted to the smokestack through a narrow pass which was expected to assist in complete mixing and combustion of gases. At first the arch was made very long, and the pass narrow, on the supposition that the narrower the pass, the more complete will be the combustion of the gases. It was found however that the distribution of temperature throughout the boiler was very unequal, and at the pass into the smokestack so high that firebricks melted and the arches fell away in less than one month. Long grates were used, with the result that coal, ashes, slag and bricks accumulated under the bars, and not less than four men had to be employed to clear it away. The long and heavy grate bars easily burned off, and as soon as about 4 in. of their length was destroyed, the bar had to be taken out, with a great loss of time and effort. Numerous tests were

made and finally the design shown in Fig. 8 was evolved, with a short arch (400 mm, or 15.7 in.), large gas combustion space, short grate bars disposed in seven steps as shown, and a more convenient system for the removal of slags. Thus reconstructed, the furnace has been in operation for over a year without repairs, burning 180 kg of coal per qm per hour (36.8 lb. per sq. ft. per hr.), with temperature at the furnace bridge 250 to 300 deg. cent. (662 to 572 deg. fahr.), and draft 6 to 10 mm (0.23 to 0.39 in.) with half closed damper, while with 20 mm (0.78 in.) draft 200 kg per qm (41 lb. per sq. ft. of coal can be burned, and 30 kg of steam per qm (6.15 lb. per sq. ft.) of heating area developed. The normal content of CO_2 from 10 to 13 per cent; CO none. At the same place tests have been made with compressed air undergrate blowing in connection with an ordinary grate, and it was found that the combustion of fuel proceeds more economically and can be more completely regulated than otherwise. With air pressure in the undergrate blower of 25-30 mm (1 to 1.18 in.) it was easy to burn 140 kg per qm (28.8 lb. per sq. ft.) grate area. The difficulty with which they had to contend in these tests was due to the absence of apparatus showing the efficiency of furnaces with undergrate draft, CO_2 recording in itself not being sufficient. These tests have, however, indicated the general usefulness of undergrate blowing with compressed air, as well as the necessity for a different type of grate bar, such as would eliminate the loss of compressed air; some method of obtaining a uniform distribution of the air blast through the fuel bed is also wanted.

Modern Experiments and Experiences with Materials for Turbine Blades for High Temperatures (*Neuere Versuche und Erfahrungen mit Turbinen-schaufelmaterial für hohe Temperaturen*, Schulz. *Die Turbine*, vol. 9, nos. 13, 14, 15, pp. 225, 243, 266, April 5 and 20, and May 5, 1913. 7 pp. *ep*). A complete compilation of data on materials for use in *superheated steam and gas turbine* construction for parts exposed to the action of hot gases and at the same time to high stresses. The author takes up one material after another, citing data of tests on its tensile strength and elongation at temperatures up to or above 500 deg. cent. (932 deg. fahr.), giving references to former investigations. Notwithstanding its high melting point, pure nickel cannot be used on account of its fragility at high temperatures. Wrought iron appears to be very suitable for superheated steam turbines [tensile strength at 932 deg. fahr., according to Dr. Kollmann, fell from 37 kg (52,600 lb. per sq. in.) to 13 kg (18,400 lb. per sq. in.), but according to Rudeloff at 400 deg. cent. (752 deg. fahr.) it still has a tensile strength of 32 kg (45,500 lb. per sq. in.) and an elongation of 40 per cent]. It is used for blades in the Thyssen and Melms & Pfenninger steam turbines. Ordinary bronzes have not proved satisfactory, but some of the special bronzes gave good results; thus, Professor Striebeck obtained good results with Durana metal (59 Cu, 40 Zn, 1 Sn, 0.4 P, 0.3 Fe) at temperatures up to 350 deg. cent. (662 deg. fahr.); nearly similar results were obtained with Resistin (a bronze containing 5 to 6 per cent of manganese): the first of these bronzes is used in the Imle turbines, the second in the blades in the superheated steam stages of the turbines of the steamer Kaiser, built by the Vulkan yards of Stettin. The Stones manganese bronze is used for blade construction in the Japanese navy. Very good results have been obtained in 1912 at the Weser Company yards in tests with Ruebel bronze, but these data cannot yet be considered as conclusive. Aluminum bronzes do not appear to have withstood long

usage, though satisfactory on short tests. As regards special steels (alloy steels), the tests of Fabry, at the laboratory of the Hungarian Royal Iron and Steel Works, have shown that at high temperatures low carbon steel is superior to high carbon. Rudeloff has found that nickel steels with 8 to 16 per cent nickel materially increase in strength when slowly cooled after heating. Carbon-free nickel-iron alloys patented for use in turbine blades by the Brown-Boveri Co., have failed in laboratory tests. Regular 5 per cent nickel steel has proved to be very efficient, while higher nickel steels (25 per cent) have not been found to be quite as good. On the other hand Guillet, on the basis of extensive tests, recommends for blades steel of 30 to 32 per cent Ni and maximum 0.12 per cent C. This steel has the further advantages that its coefficient of expansion is small, and that it does not rust in clean water. As regards Monel metal, there is little doubt as to its good qualities, especially in the composition 68 per cent Ni, 27 per cent Cu, and the rest iron and manganese, but it is so hard that it cannot be conveniently rolled, at least that has been the experience of the firm Heckmann in Germany which finally discontinued its manufacture. It makes, however, turbine blades of a softer material, with 65 per cent Ni content. Hörenz and Imle are now making tests with Monel blades in turbo-blower blades, but the data have not been published yet; it appears, however, that at red heat the metal is malleable, and after being once heated to redness does not oxidize further. The article gives also some data as to another nickel alloy called "Chronin," but does not indicate its composition. Chrome-nickel alloys, with 25 and more per cent Cr, have a high resistance to chemical influences, but are not malleable and cannot generally be shaped mechanically. The addition of 1.5 to 2.5 per cent silver (30 per cent chrome, rest Ni: patent Borchers) is said to improve materially the mechanical qualities of the alloy, so that it can be machined in the usual manner.

Strength of Materials and Materials of Construction

On the Elastic Limit of Alloys (*Sur la limite élastique des alliages*, A. Portevin. *Comptes rendus de l'Académie des Sciences*, vol. 156, no. 16, p. 1237, April 21, 1913. 4 pp., 6 figs. *e*). One of the methods of determining the *elastic limit* of metals and alloys is that of *slip-bands*. The author made a series of tests with alloys, using, for simplicity's sake, alloys which have preserved at the ordinary temperature their crystalline structure of solidification, that is, have not after solidification passed through either intentional deformation or secondary recrystallization. The tests were made with: (*a*) alloys formed of a single, solid, chemically homogeneous, solution (slip bands appeared first in certain grains only and gradually spread out to all the grains; the sections of maximum and minimum limits of elasticity may be determined, by noting the sections where the initial and complete deformation occur first); the author observes in this connection that the limit of elasticity which is a vectorial quantity in a single grain, becomes a scalar for the entirety of the piece only because of the lack of uniformity in the orientation of the crystals. (*b*) In alloys formed of a single, solid, chemically heterogeneous, solution, the chemical composition varies in each crystalline aggregate from the center to the periphery, the central parts having the highest melting point. Each crystal will behave in the same way as in the preceding case, with that difference, however, that the elastic limit of the central part is not the same as that of the periphery, the slip-bands appearing first in the part of the crystal having the lowest elastic limit. (*c*) In the case of a complex of two phases, e. g. brass with a 57 per cent content of

copper, there are two constituents, and the slip-bands appear first in one of them (*a*). All these observations tend to show that the curve of load-deformation is *continuous*, and cannot be therefore set precisely in one definite quantity (elastic limit): in fact, it extends between limits which depend both on mechanical anisotropy of the crystals, and degree of chemical homogeneity of the alloy.

Lineal Expansion of Solids by Heat at Higher Temperatures (*Thermische Ausdehnung fester Körper bei höheren Temperaturen*, A. Werner. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 19, p. 227, May 9, 1913. 3 pp., 8 figs. *e*). Description of some experiments on, and methods used for, the

TABLE 2 LINEAL EXPANSION BY HEAT OF NICKEL STEEL

Temperature, Deg. Cent.	Lineal Expansion in millimeters per Meter of Material Percentage of Nickel in Steel			
	5	25	25	33
0	0.000	0.000	0.000	0.000
50	0.472	0.731	0.741	−0.009
100	1.003	1.564	1.608	+0.009
150	1.589	2.471	2.556	0.119
200	2.203	3.418	3.545	0.386
250	2.833	4.378	4.527	0.876
300	3.465	5.322	5.464	1.651

The two columns for 25 per cent nickel steel correspond to test pieces of different origin.

determination of the coefficient of lineal expansion of solids at higher temperature in the laboratory of the Physikalisch-Technische Reichanstalt (for a fuller description of this new apparatus see A. Leman and A. Werner, *Zeits. für Instrumentenkunde*, 1913, no. 3, p. 65). The lineal expansion is determined relatively to that of quartz glass which is convenient since the expansion of quartz glass has been determined with great precision up to 1000 deg. cent. (1832 deg. fahr.). Table 2 shows the data obtained for the expansion of nickel steel with various percentages of nickel, interesting because of the wide use of nickel steel in automobile and steam turbine construction.

Enemies of Reinforced Concrete (*I nemici del cemento armato*, Professor Rohland. *Verkehrtechnische Woche*, April 26, 1913, through *L'Ingegneria Ferroviaria*, vol. 10, no. 9, p. 137, May 15, 1913. *p*). A review of various influences affecting the strength and durability of reinforced concrete (action of water of various composition, earth, and electric currents), and explanation of the underlying chemical phenomena.

Experiments on the Distribution of Stresses in Notched Bars under Tension (*Versuche über die Spannungsverteilung in gekerbten Zugstäben*, Dr. Ing. E. Preuss. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 134, 1913. p. 47, 15 pp., 30 figs. *e*). Experimental investigation on the distribution of stresses in notched bars under tension, to be read in connection with the author's former investigation on the distribution of stresses in punched bars (*The Journal*, February 1913, p. 341). For notched bars the author shows that (*a*) in bars with equal depth of notch, the stress at the notch edge is inversely proportional to the diameter of the notch; (*b*) in bars with equal

diameters of notch and equal notch widths, the stress at the notch edge is proportional to the depth of notch; (*c*) when the notch is semicircular, the stress at the notch edge is inversely proportional to the diameter; (*d*) it has been found that, with the exception of the case of sharp cornered notches, the stress at the notch edge is from 1.43 to 2.48 greater than the usually assumed average stress; (*e*) the minimum stress along the middle axis of the bars in the bars tested is subject to stresses 0.71 to 0.98 times the average stresses.

Miscellanea

Washing, Bathing and Dressing Rooms in Factories (*Wasch- und Bade-, sowie Ankleideraume in Fabriken*, H. W. *Sozial-Technik*, vol. 12, no. 10, p. 187, May 15, 1913. 3 pp. *p*). A practical discussion of the question of providing workmen with washing, bathing and dressing facilities, and the best types of furniture and apparatus to be used in this connection. The author points out that the fact that the workmen sometimes do not make as much use of the facilities provided for them as could be expected, is due mainly to the unsatisfactory arrangement or location of the rooms, forcing the men to lose much time in reaching them or in waiting for their turn to use the washstands. Often also the washrooms are kept in a state such as to make their use repulsive. On the other hand, the training of workmen in orderliness and cleanliness is of advantage both to the men and the employer, and in some trades, e. g. where poisonous substances are used, of absolute necessity. The author recommends the use of separate washrooms for the different shops rather than a common place for the entire factory, both because of their better accessibility, and because it is advantageous to keep the separate groups of men as much apart as possible.

Smokestack Construction with Special Regard to Accident Prevention (*Schornsteinbau unter besonderer Berücksichtigung der Unfallverhütung*, H. Dieckhoff. *Sozial-Technik*, vol. 12, no. 9, p. 161, May 1, 1913. 8 pp., 7 figs. *dA*). Discussion of the main *safety devices* to be used in smokestack construction. The author is owner of a well-known firm of smokestack constructors in Germany. The removal of old smokestacks is also briefly discussed.

Sound Conductivity of Building Materials and Walls (*Über Schalldurchlässigkeit von Baumaterialien und ausgeführten Wänden*, R. Ottenstein. *Gesundheits-Ingenieur*, vol. 36, no. 19, p. 345, May 10, 1913. 4 pp., 3 figs. *e*). A preliminary publication of data of an investigation on *sound conductivity* in various materials and structures. Information about this investigation has already been published in *The Journal* (March 1912, p. 430); a fuller account will be given after the complete publication of the data of the original investigation. From the data published in this article it appears that the increase in the weight of the sound-protecting plate or wall is proportional to the useful effect obtained only up to a certain limit, beyond which the sound conductivity of the plate decreases much slower than the increase in weight. The fundamental condition of sound protection is the best possible airtight division between the spaces in question; heavy walls afford a better protection against transmission of sound, due to their higher resistance to the rise of oscillations; air spaces between oscillating walls lessen the dampening action of the walls; air spaces between porous walls or a porous and a solid wall are harmful, and packing of loose material between such walls is of little help, since it does not offer sufficient resistance to the propagation of sounds. A method for the determination of sound conductivity in walls is described.

ARTICLES UPON GAS POWER

(Prepared by the Gas Power Literature Committee)[1]

Betriebserfahrungen mit Dieselschiffen. *Zeitschrift des Vereines deutscher Ingenieure*, March 29, 1913. ½ p. *p*.

Marine operating experience with the Diesel engine.

Flugzeugmotor, Die Durchführung und das Ergebnis des Wettbewerbes um den Kaiserpreis für den besten deutschen, F. Bendemann and Seppeler. *Zeitschrift des Vereines deutscher Ingenieure*, May 3, 1913. 6 pp., 23 figs. *p*.

The conduct and result of the competition for the Emperor's prize for the best German flying-machine motor.

Gemischbildung in Gasmaschinen, Zeichnerische Untersuchung der, J. Magg. *Zeitschrift des Vereines deutscher Ingenieure*, May 3, 1913. 3½ pp., 3 curves. *m*.

Graphic investigation on the mixture formation in gas engines.

Steuerungsdiagramm für Viertaktmaschinen, J. Magg. *Zeitschrift des Vereines deutscher Ingenieure*, February 15, 1913. 2 pp., 6 figs. *m*.

Article on valve-gear diagram for four-stroke cycle engines.

Verbrennungskraftmaschinen uns der Weltausstellung in Gent, P. Meyer. *Zeitschrift des Vereines deutscher Ingenieure*, May 17, 1913. Serial article. *dp*.

Internal-combustion engines at the World's Fair in Ghent.

Verbrennungsmotoren und ein neuer Sechstaktmotor, Die Steigerung der Leistung von, Emil Schimanek. *Zeitschrift des Vereines deutscher Ingenieure*, January 25, 1913. 7¾ pp., 11 figs., 2 tables, 8 curves. *mp*.

Increasing the duty capacity of internal-combustion engines and a new six-stroke cycle engine.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

MEETING

SAN FRANCISCO MEETING, MAY 15

A meeting of the San Francisco Section of the Society was held on Thursday evening, May 15, in the rooms of the Commercial Club. G. L. Bayley, Mem.Am.Soc.M.E., chief mechanical and electrical engineer of the Panama-Pacific International Exposition Company, read a paper on the progress of the buildings being erected for the exposition, illustrating his remarks with lantern slides.

BOSTON MEETING, MAY 23

A meeting of the Boston Section of the American Institute of Electrical Engineers, in which the members of the Society were invited to participate, was held on Friday evening, May 23, in the Edison Company Auditorium. The paper of the evening was upon the Organization and Methods of a Large Engineering and Construction Company, presented by Roy M. Henderson, vice-president and construction manager of the Stone & Webster Engineering Corporation. In it he sketched the steps in the development of the business leading up to the present organization and outlined the latter in detail with special reference to the engineering, construction, purchasing and accounting staffs. He described also the scheme of local organization for field operations.

STUDENT BRANCHES

CASE SCHOOL OF APPLIED SCIENCE

On May 8, the Mechanical Engineering Club of Case School of Applied Science elected the following officers for the coming year: chairman, H. C. Mummert; vice-chairman, S. Kenyon; secretary, C. Stemm; treasurer, S. Stanley; senator, L. F. Milligan.

The paper of the evening was Coal and Ashes Handling Machinery, by David Gaehr, Mem.Am.Soc.M.E. It was the first time the lecture was given and the author had prepared many original slides to illustrate his talk. A social gathering followed.

PURDUE UNIVERSITY

At a meeting of the Purdue Student Section held May 20, the following officers were elected for the coming year: chairman, A. D. Meals; vice-chairman, J. M. Lonn; recording secretary, R. E. Kriegbaum; treasurer, W. T. Miller; program committee, S. A. Peck and F. G. Spencer; corresponding secretary, G. F. Lynde; members of the governing council, C. W. Handley and E. A. Tuttle.

UNIVERSITY OF CINCINNATI

The annual election of officers of the Student Branch of the University of Cincinnati was held May 27 with the following results: chairman, A. O. Hurxthal; vice-chairman, R. M. Race; secretary and treasurer, E. A. Oster.

Preceding the election, Charles S. Gingrich, Mem.Am.Soc.M.E., addressed the section on The Engineer, discussing the municipal and economic problems confronting him, and his relation to capital and labor.

UNIVERSITY OF ILLINOIS

At the last meeting of the year held on May 23, the Student Branch of the University of Illinois elected the following officers: chairman, A. H. Aagaard; vice-chairman, Geo. Meyer; treasurer, H. C. Peterson; secretary, H. E. Austin.

The program for the afternoon consisted of a paper on The Design of Gas Tractors, by E. J. McCormick.

NECROLOGY

ADOLPHUS BONZANO

Adolphus Bonzano, pioneer bridge builder and inventor of the Bonzano rail joint and other railroad appliances, was born at Ehingen, Germany, December 5, 1830. He received a classical and engineering education both at Ehingen and at Stuttgart, and in 1850 came to America to perfect himself in the study of English. In 1851 he went to Springfield, Mass., where for the following four years he served as apprentice, machinist and draftsman for the American Machine Works. Until 1860 he was engaged as superintendent of construction of the Detroit Dry Dock Iron Works, which was later transformed into the Detroit Bridge & Iron Works, one of the earliest bridge building plants in this country. In 1868 he moved to Phoenixville, Pa., where with Thomas Curtis Clarke and others he formed the firm of Kellogg, Clarke & Company, bridge builders, he acting as chief engineer. In 1884 this firm was dissolved and was succeeded by the Phoenix Bridge Company, of which Mr. Bonzano was made vice-president and chief engineer. In 1893 he resigned this position and with Mr. Clarke opened an office in New York as consulting engineers. After his partner's death in 1898, Mr. Bonzano retired from active business to devote himself to the invention of railroad and other appliances. The Pecos viaduct on the Southern Pacific Railroad in Texas, the Kinzua viaduct on the Erie Railroad, and the Chesapeake & Ohio bridge at Cincinnati are among the more notable examples of his work. He died May 5, 1913.

HORATIO A. FOSTER

Horatio A. Foster was born at Bustleton, Philadelphia, Pa., January 12, 1858. His engineering training began in the fall of 1884 with the Daft Electric Company, Greenville, N. J.; the next year he went to Baltimore to electrify a short branch of the Baltimore Union Passenger Railway Company. In 1886 he entered the shops of the Thomson-Houston Electric Company at Lynn, Mass., and in September 1888 was appointed superintend-

ent of the East River Electric Light Company, New York, remaining with that company till July 1891. He was then appointed an expert for the United States Census office to compile data on the electrical industry of New York State. In May 1893 he accepted a position in the editorial department of Electric Power, and later in the same year became associated with George Forbes, electrical engineer of the Niagara Falls Power Company, and had charge of his New York office for about a year and a half. In 1895 Mr. Foster joined the staff of the Cataract Construction Company of Niagara Falls as testing engineer. After several years in general consulting work he became interested in the valuation of public utilities, studying traffic conditions and other matters pertaining to public service, being engaged in this work with J. G. White & Company at the time of his death, April 27, 1913.

Mr. Foster was the author of the Electrical Engineers Pocket-Book, which bears his name, also Valuation of Public Utilities, and he had frequently contributed to the technical press. He was a member of the American Institute of Electrical Engineers, the Engineers Club of New York, and the Philadelphia Arts Club.

PETER KIRKEVAAG

Peter Kirkevaag was born in Christianssund, Norway, April 1849, and in 1871, after finishing an apprenticeship, he went to Germany with a stipend from the Norwegian government. He was graduated from the polytechnic school in Langensalza, Turingen, in 1874 and was afterwards employed as draftsman and engineer in Westphalia until 1877, following which he was inspector for three years for the Nordenfelth gun factory in Stockholm, Sweden. In 1881 he came to the United States, where he secured employment as machinist and draftsman with Oliver Brothers & Phillips and A. Garvison & Co., Pittsburgh, Pa. Two years later he became draftsman and superintendent of buildings, foundations, etc., for the Hartman Steel Company, Beaver Falls, Pa., and this same year saw the beginning of his connection with William Tod & Company, Youngstown, Ohio. Thirty years later he left this company to become associated with the Brier Hill Steel Company of the same town. He died May 6, 1913.

HAROLD SERRELL

Harold Serrell was born in Brooklyn, N. Y., August 26, 1852. Having completed his education at Adelphi Academy in 1869,

he entered the office of his father, Lemuel Wright Serrell, patent attorney and expert in patent causes, with whom he was associated under the firm name of L. W. Serrell & Son. After his father's death in 1899, he carried on the business alone, studying and familiarizing himself with machinery, mechanical devices and the arts and sciences for the professional career of solicitor of patents and mechanical expert. He served in contested cases as mechanical expert, giving testimony both in court and before a master for use in court. He died February 26, 1913.

OLIN SCOTT

Olin Scott was born February 27, 1832, at Bennington, Vt., where he learned the trade of a millwright. In 1858 he formed a partnership with H. S. Brown and established the Bennington Machine Works; in 1863 he purchased the interests of his partner and in 1864 purchased and combined the business of the Eagle Foundry and Machine Works. Later this foundry developed into a factory for the manufacture of powder mill and pulp mill machinery. Before the use of nitro powders became general, the Bennington Machine Works had acquired a national importance and worldwide reputation, machines from its shops having been shipped to every continent on the globe. After the close of the Civil War Colonel Scott ceased to confine his energies exclusively to manufacturing and became an organizer of powder manufacturing companies. In 1869 he built the Lake Superior Powder Mills at Marquette, Wis., and four years later he became superintendent of the Laflin and Rand Powder Company of New York. In 1882 he organized the Ohio Powder Company of Youngstown, Ohio, and for several years was vice-president of the corporation. He also organized the Pennsylvania Powder Company at Scranton, Pa., in 1884, becoming its president. Three years later he disposed of his interests in Ohio and Pennsylvania and became a consulting engineer for the Laflin and Rand Company and the Dupont Powder Company of Wilmington, Del., a position he retained until 1894. In 1892 he became president of the Lasher Stocking Company and operated the property until its comparatively recent disposition to the Vermont Hosiery and Machinery Company.

Colonel Scott died in Bennington, April 28, 1913.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

Academy Architecture and Architectural Review. Classified index to vols. 1–21, 1889–1902. *London, 1902.*

American Wood Preservers' Association. Proc. 9th annual meeting, 1913. *Baltimore, 1913.* Gift of association.

Asphalt Construction for Pavements and Highways, Clifford Richardson, 1913.

Association of Railway Electrical Engineers. Proc. vol. 5, 1912. *Chicago, 1912.* Gift of association.

British Fire Prevention Committee. Journal no. 10, 1913. *London, 1913.*

Cassier's Magazine (London). Oil Power Number, March 1913. *London, 1913.* Gift of W. R. Haynie.

Celluloid Dangers with Some Suggestions. British Fire Prevention Committee, no. 179. *London, 1913.*

Connecticut. Bureau of Labor Statistics. 25th Report, 1912. *Hartford, 1912.* Gift of bureau.

Conservation of Water Powers, R. G. Brown. *Washington, 1913.*

Dictionary of Automobile Terms, A. L. Clough. *New York, 1913.*

Diesel Liquid Fuel Engine, W. J. Dyer. Before Hawaiian Engineering Association. *Honolulu, 1913.* Gift of author.

The Engineer's Yearbook for 1913, H. R. Kempe. *London, 1913.*

Gas Engine in Modern Blast Furnace and Steel Plants, Heinrich J. Freyn. Gift of author.

Gasoline Automobile, Its Design and Construction, P. M. Heldt. vol. 2. Transmission, running gear and control. *New York, 1913.*

Industrie und Ingenieurwerke in Mittel und Niederschlesien. Festschrift zur 52 Hauptversammlung des Vereines deutscher Ingenieure in Breslau June 10–14, 1911. *Breslau, 1911.* Gift of Verein deutscher Ingenieure.

Investigation of the conditions governing thr choice of a Proper Quality Standard for artificial gas with conclusion and recommendation of the Joint Committee on Calorimetry of the Public Service Commission and Gas Corporations in the Second Public Service District New York State. Gift of Empire State Gas and Electric Association.

Leland Stanford Junior University. Register 1912–1913. Gift of university.

Light: Its Use and Misuse. A primer of illumination prepared under the

direction of the Illuminating Engineering Society. *New York, 1912.* Gift of Calvin W. Rice.

Lowell Textile School. Bull. 1913–1914. *Lowell, 1913.* Gift of school.

Die Maschinen-Getriebe, Wilh. Hartmann. vol. 1. *Stuttgart, 1913.*

Mecanique, Electricité et Construction Appliquées aux Appareils de Levage, Louis Rousselet. vols. 1 and 2. *Paris, 1908, 1913.* Gift of Hunt Memorial Fund.

Milwaukee, Wis. Smoke Inspector. Annual Report 1912. *1912.*

Monthly Official Railway List, May 1913. *Chicago, 1913.*

New York State Charities Aid Association. Annual Report 1912. *New York City, 1912.* Gift of association.

Ohio University. Catalogue 1913–1914. *Athens, 1913.* Gift of university.

Principles of Irrigation Engineering, F. H. Newell and D. W. Murphy. *New York, 1913.*

Purification of New York Harbor, G. A. Soper. Reprinted from the Medical Record, May 17, 1913. *New York.* Gift of author.

Rhode Island. Public Utilities Commission. Annual Report 1912. *Providence, 1913.* Gift of commission.

Schweizerischer Ingenieur und Architektenverein. Staats und Handelswissenschaftlicher Kurs, 1913. Gift of Schweizerischer Ingenieur und Architektenverein.

Specifications for Street Roadway Pavements, S. Whinery. ed. 2. *New York, 1913.*

Stone & Webster Engineering Corporation. Brief data regarding various water power plants. *Boston.* Gift of Calvin W. Rice.

Street Railway Journal. Advertisements, vols. 7–32. *New York, 1891–1908.* Gift of H. W. Blake.

Technischen Staatslehranstalten in Chemnitz. Reiseberichte über das technische und gewerbliche schulwesen Nordamerikas. Abhandlungen und Berichte February 1913. *Chemnitz, 1913.* Gift of Technischen Staatslehranstalten in Chemnitz.

Treatise on Hydraulics, W. C. Unwin. ed. 2. *London, A. & C. Black, 1912* Gift of author.

The first edition was published in 1907. This second edition has added a short summary of more recent researches on the measurement of flow.

U. S. Interstate Commerce Commission. 26th Annual Report. *Washington, 1913.* Gift of commission.

University Business Administration, J. C. Christensen. *1912.* Gift of author.

Visit to Germany of the American Society of Mechanical Engineers on the Invitation of the Verein deutscher Ingenieure, 1913. Gift of Verein deutscher Ingenieure.

Die Wasserkräfte ihr Ausbau und ihre wirtschaftliche Ausnutzung, Adolf Ludin. vols. 1–2. *Berlin, 1913.*

Zeitschriften der gesamten Eisenbetonliteratur 1912, A. Fitzinger. *Berlin, 1913.*

EXCHANGES

Deutschen Museums. Verwaltungs-Bericht über das neunte Geschäftsjahr 1911–1912. *München, 1912.*

Liverpool Engineering Society. Trans., vol. 33. *Liverpool, 1912.*

Municipal Engineers of the City of New York. Proc. 1912. *New York, 1913.*

Society of Naval Architects and Marine Engineers. Trans. vol. 20, 1912. *New York, 1913.*

UNITED ENGINEERING SOCIETY

Kansas Gas and Electric Light Street Railway and Water Association. List of Members. *1913.* Gift of association.

Library of Congress. Classification. Class Q, Science. *Washington, 1913.* Gift of library.

New York Public Library. List of Works relating to Electric Welding. *New York, 1913.* Gift of W. B. Gamble.

Report of the Committee appointed pursuant to House resolutions 429 and 504 to investigate the Concentration of Control of Money and Credit. February 28, 1913. Gift of House.

TRADE CATALOGUES

Bristol Company, *Waterbury, Conn.* Bull. 143, Recording differential pressure gages and recording flow-rate meters, April 1913; Bull. 170, Patent electric furnaces for soldering coppers, April 1913; Cat. 173, Recording differential pressure gages and recording flow-rate meters. Float type, model 1010, April 1913; Cat. 1300, Bristol's Class III frecording thermometers, April 1913.

Chicago Pneumatic Tool Co., *Chicago, Ill.* Bull. 34L, General pneumatic engineering information, April 1913; Bull. 128, Miscellaneous equipment for pneumatic drills, April 1913; Bull. 132, Pneumatic motors and pneumatic geared hoists, April 1913; Bull. 138, Cylinder air hoists and jackets, April 1913.

Holophane Works, *Cleveland, Ohio.* Bull. 28, Decorative shades, March 1913.

Johns-Manville Co., *Cleveland, Ohio.* J-M Power Expert, May 1913.

Westinghouse-Church-Kerr & Co., *New York, N. Y.* Work done (no. 5), railroad shop edition, 47 pp.

North Western Expanded Metal Co., *Chicago, Ill.* Expanded metal construction, June 1913.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

601 First class automobile engineer or designer for Indianapolis concern. Familiar with latest pleasure car construction. Must have had several years' experience in engineering department of established automobile concern.

603 New York concern wants draftsman for heating, ventilating and piping work. Salary \$20-\$25.

604 Head draftsman thoroughly familiar with construction of cranes and hoists, both hand and power and electric. Must be man of executive ability and capable of taking contract through.

605 Head of engineering department for concern manufacturing boilers, engines, tanks and water-heaters. Salary ranging from two to three thousand dollars a year. Location Dayton, Ohio.

606 Wanted by agricultural machinery works in Middle West, employing 700 men, rate setter qualified by thorough experience in machine shop to figure accurately allowed times on various operations, both wood and metal work. Practical man preferred. Must be broad minded and deal fairly with men, yet safeguard interests of the management. Position one of importance and responsibility.

607 Wanted a rate setter, a man who can operate all kinds of machine tools, especially turret lathes, millers, and grinders, and has had experience making time studies for piece-rate setting. Location New York State.

MEN AVAILABLE

139 Junior member, A.B. Yale, M.E. Columbia, would like to associate with engineer or firm making specialty of design and construction of industrial plants. Experienced as superintendent of construction, assistant to works manager, etc.

140 Member, Junior grade, Cornell graduate, with three years' experience in large public service corporation. Available about August first.

141 Member, technical graduate, three years' experience as instructor in mechanical engineering, eight years' experience as draftsman, head draftsman, assistant superintendent and sales engineer with responsible engine building concerns, would consider position as instructor in reputable institution.

142 Member, technical graduate, desires position as sales engineer with

high class concern. Has had wide experience as draftsman, head draftsman, assistant superintendent and sales engineer with reputable engine builders.

143 Member desires change of location. Graduate mechanical engineer with twenty years' experience in the design and manufacture of gasoline, steam, and electric locomotives, gas engines; good organizer and up-to-date in modern shop management. Prefers position as superintendent or assistant east of Mississippi River.

144 Graduate in mechanical engineering; experience in design and construction and testing of boilers.

145 Junior, technical graduate, nine years' experience in power plant and factory work, desires position as assistant to works engineer or manager; or teaching in steam and experimental engineering.

146 Mechanical engineer, 29, graduate M. I. T., excellent experience in design of industrial plants and mechanical equipment of buildings, desires permanent connection with firm of consulting or mill engineers or position as plant engineer. Location in or near New York.

147 Member, mechanical engineer and expert machinist, with ten years' experience in manual, industrial and vocational education, desires executive position along this line; best references.

148 Member desires new connection as chief engineer and factory architect or chief construction engineer. Successful designer of large manufacturing plants and special machinery, including structural steel, reinforced concrete, power plants, heating, ventilation and refrigeration. For several years head of department of mechanical engineering in large college and is open for similar position at good institution.

149 A mechanical engineer, with nine years' experience with engine works and twelve years as dean of a prominent college of mechanical and electrical engineering, has been granted a leave of absence for the coming year and would like to become associated for the next twelve or fourteen months with some reputable firm of engineers.

150 Member, graduate of Stevens Institute and post-graduate Cornell, at present dean of engineering and professor of mechanical engineering in Western college, desires to make a change.

151 Member, specialist in steam turbines, desires to make connection with firm for the manufacture of fully developed and tested cheap commercial turbine, suitable for sizes up to 1000 h.p., condensing as well as non-condensing operation.

152 Manufacturing accountant and practical shop man, 18 years' experience with best accounting and shop practice connected with steel and rolling mills, iron, steel and brass foundries, bridge and structural shops, ship yards machine shops, woodworking shops, etc., familiar with manufacture of internal combustion engines, stationary and tractor; steam and power pumps, threshing machinery and electrical machinery, etc.; competent to handle factory reorganization work of large and small companies.

153 Mechanical engineer with several years' experience, located in manufacturing district of Eastern Pennsylvania, would like to hear from engineers or manufacturers who desire special opportunities for sales investigations without the necessity of sending own representatives.

154 Member, at present with large ball and and roller bearing concern.

as engineer in charge of automatic machinery, wishes to connect with some reliable concern manufacturing fine interchangeable parts or machines: high class executive, with 14 years' experience in the use and design of automatic machinery and standard machines of this class.

155 Mechanical engineer salesman in Cuba, Hawaii or South America; valuable experience in the producer gas power field as an inventor, designer, engineer and salesman; speaks Spanish.

156 Associate, age 35, with 17 years' broad experience in drawing-rooms on civil, structural and mechanical work, desires a position of some responsibility, in or near Philadelphia. Experience on furnaces, steel plants, mill work, power plants, chemical apparatus, gas plants, coke ovens, etc.

157 Member, at present employed, 18 years' varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of large industrial plants and equipment, systematizing of shops and processes along the lines of scientific management, testing and general plant engineering; accustomed to handling men, drawing up contracts, purchasing equipment and material, appraising properties; desires to become identified with manufacturing or industrial plant of prominence in administrative or executive position of responsibility.

158 Graduate mechanical engineer (Stevens), 23 years of age, desires position with good prospects of advancement. Has had one year's experience in full charge of general construction work, ordering all material, handling correspondence, and checking accounts, installation of safety devices. Excellent references. At present employed.

159 Business manager, 40. Twenty years' experience, comprising experimentation, designing, selling, works management, factory building and organization. Technical gradute. Has been engaged for two years in business other than manufacturing, but desires to re-enter engineering field as executive or engineering representative.

160 Mechanical engineer, technical education, 30 years of age, 10 years' practical experience, in design, construction, operation, maintenance and reorganization of mill, factory, and other manufacturing properties. Wide experience in the superintendence of central power stations, factory extension, mill and reinforced concrete construction work. Desires position of mechanical superintendent or master mechanic. Particularly experienced in practical efficiency work. At present employed.

161 Technical graduate of an Eastern school, age 26 years, would like to engage in cost and efficiency work. Experience consists of work in the shops as well as along commercial lines. Employed at present.

162 Member, mechanical engineer, desires to hear from manufacturers of power plant equipment and specialties who desire a representative in Pittsburg and vicinity. Would like to represent some home manufacturing engines, boilers, conveying apparatus or supplies; has been for fifteen years the expert in large steel manufacturing plants, listing all power machinery and acting in an advisory capacity in matters relating to improvement of power.

163 Member, 38 years of age, Cornell M.E., married. Wide experience in design, construction and erection of power plant machinery, including construction of boilers, engines, pumps, condensers, etc. At present engaged in general consulting work in power plant design and installation and mill

building, and for the past three years in general charge of testing work for one of the largest electric light power plants in the East. Would be willing to accept responsible position requiring full time.

164 Junior member, 28 years of age. Cornell M.E., four years' practical experience in design and construction of steam turbines, patent office work, street railway, etc. Desires position as assistant to executive, or as works manager or factory manager, or would accept a position which would lead to one of these.

165 Technical graduate in mechanical engineering, with master's degree, age 27, four and one-half years' practical experience, partly drafting and designing, mostly experimental work with steam and gas tractors, desires a position with a company manufacturing power farming machinery.

166 Member, age 40, holding M.M.E. degree from Cornell University, varied experience in teaching, designing, construction and operation. Especially qualified to manage an industrial plant or hold a position of economic engineer. For the past two years has managed successfully a small electrical supply house.

167 Sales manager and engineer, with 10 years' experience selling steam power plant apparatus in New York district, desires position where acquaintance among engineers and architects, heating and electrical contractors would be of advantage.

168 Graduate mechanical engineer, 5 years' experience in steam pump and air compressor work, also high speed automatic engine and boiler design, desires supervisory position with a manufacturing concern or a firm of consulting engineers. At present employed as chief engineer of a large engine and boiler shop.

169 Member, age 35, also member of two British societies, college education, medallist, 15 years' varied experience in gas, electrical, general mechanical and automobile engineering, works management, accustomed to responsible positions and control of large staff, seeks responsible post. Good references.

170 Member, 47, graduate M. I. T., experienced as sales manager and executive with large manufacturing corporations, wants position in sales or publicity department of some company convenient to New York and Connecticut. Capable of taking entire charge large selling force, organizing and conducting publicity campaigns or acting as assistant to chief executive; has made special study of scientific employment methods and individual productive efficiency. At present with well known corporation, but future possibilities too limited.

171 Member, specialist in scientific employment and personal efficiency methods, wants position with Eastern manufacturing concern having an annual pay-roll of not less than $500,000, in which definite results will assure a permanent affiliation with adequate salary.

172 Mechanical engineer with practical machine shop experience, technical education, three years' experience in elevating, conveying, mine and power transmission machinery, desires position as sales engineer with firm or representative located in Pittsburgh.

173 Young engineer, graduate Stevens Institute of Technology, experience in electrical engineering in consulting engineer's office. Desires to change for prospect of advanced work in mechanical lines.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913

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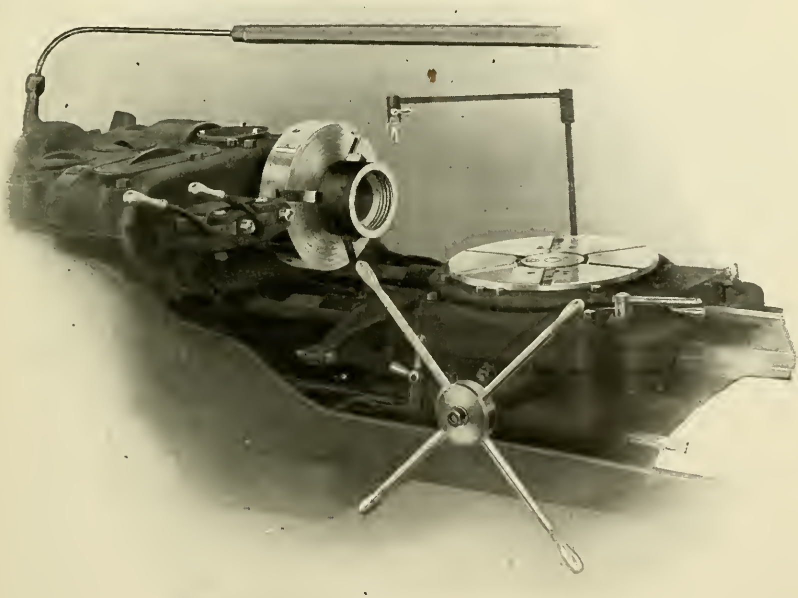

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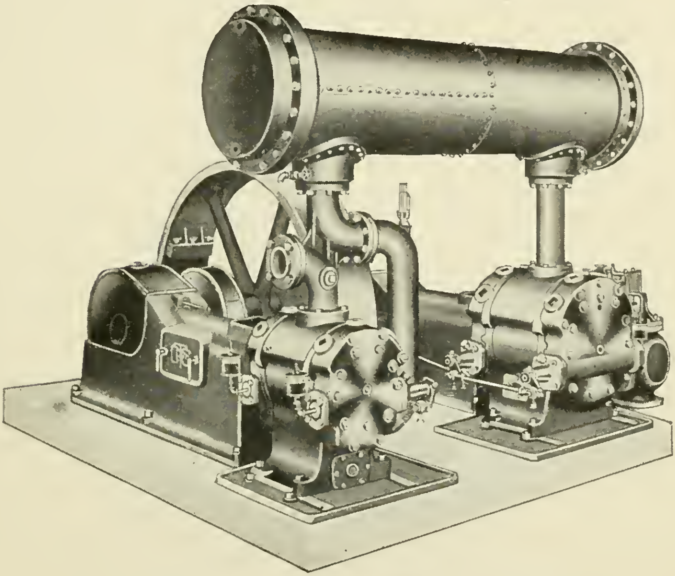

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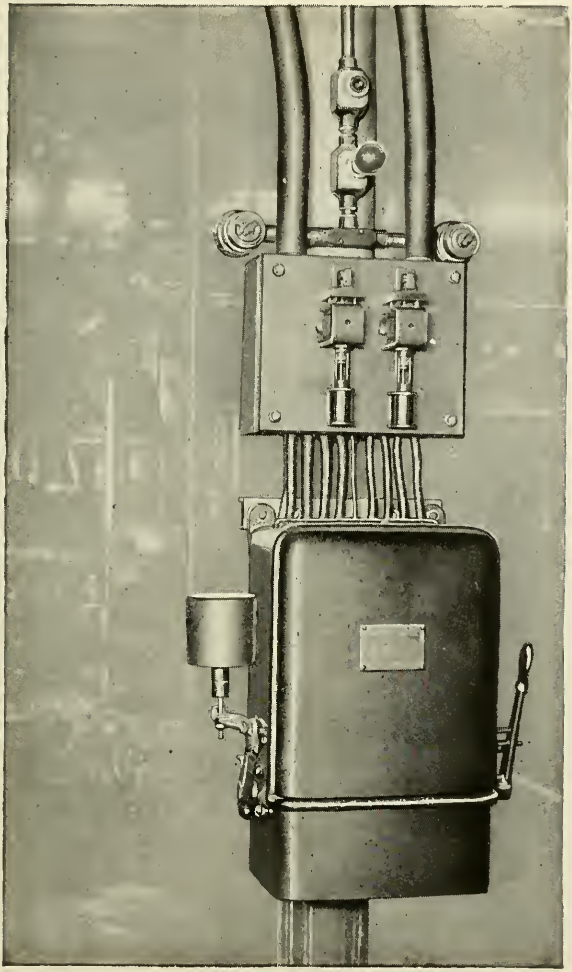

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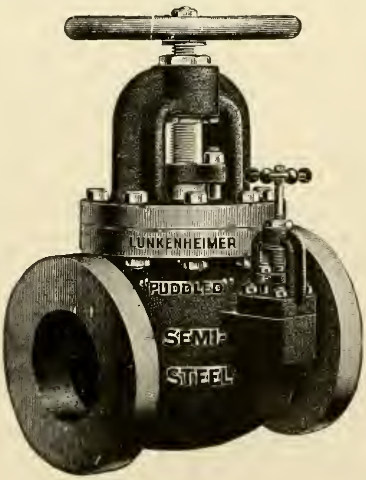

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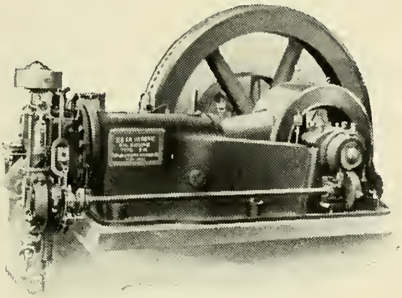

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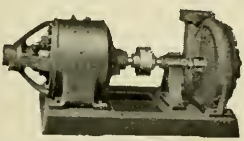

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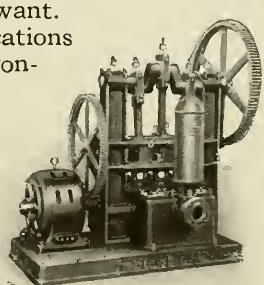

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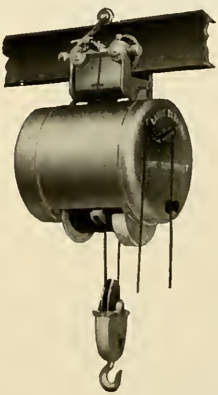

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OF

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SECTION ONE (Part Two)

Power Plant Equipment

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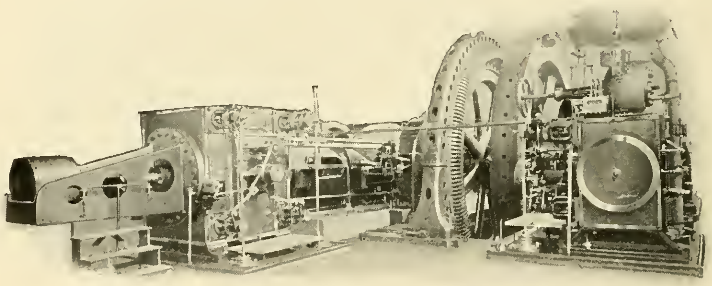

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Scientifically designed to meet the severest demands of modern practice; built for high steam pressures and greater rotative speeds than customary, equipped with sensitive governor, insuring extremely close regulation. Every line suggests rigidity and stability.

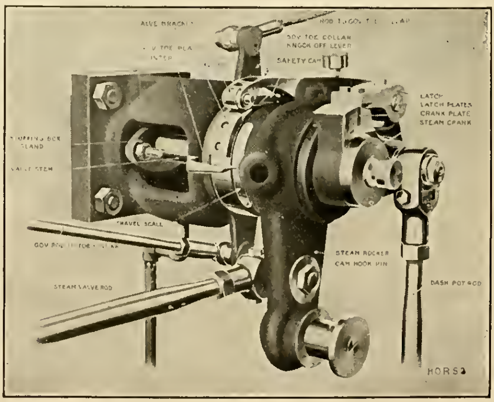
Steam and exhaust passages in the cylinders are very large, permitting low steam velocity, indicator cards showing horizontal admission and exhaust lines; volumetric clearance small, reducing steam consumption. Steam and exhaust mechanism are usually operated by separate eccentrics, giving long range cut-off. Valves double ported and motion of all parts small, consistent with good practice.

The valve gear as shown is of the releasing gravity type and is compact and simple, having very few parts. It operates noiselessly and positively at speeds up to and including 160 RPM and being a gravity gear the latch drops into place without the necessity of springs. The parts subject to stresses, such as latch and cam levers, are steel forgings, absolutely safe against breakage, and the entire valve gear is carried close to the cylinder, avoiding excessive overhang.

Frame is of the Rolling Mill type and cast in one piece; it has a broad footing on the foundation for its entire length and extends around and under crank disc.

Special tools are used for machining large castings, such as cylinder or frame, at one setting, insuring perfect alignment.

We build our heavy duty and high speed engines in both the horizontal and vertical single cylinder or compound design.



Hamilton Corliss Gravity Valve Gear

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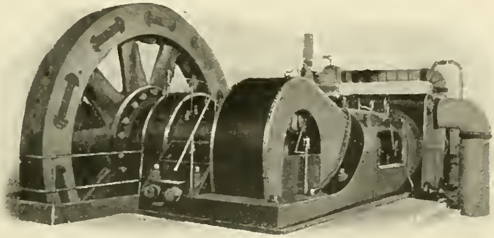
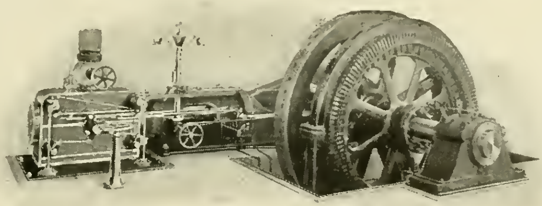


Tandem Compound Corliss Rolling Mill Engine

TANDEM COMPOUND HAMILTON HIGH SPEED CORLISS ENGINE WITH VARIABLE SPEED VALVE GEAR

This engine is equipped with positive driven valve gear and link motion with variable speed hand regulating cut-off mechanism and is arranged for direct connection to centrifugal pump or blower. It is provided with a fly ball governor, attached to a quick closing auxiliary throttle valve. The frame used in this engine is of same design as our heavy duty engine and the speed is usually from 125 to 175 RPM.



Single Cylinder Direct-Connected Corliss Engine

SINGLE CYLINDER AND COMPOUND HAMILTON HIGH SPEED CORLISS ENGINE WITH NON-RELEASING VALVE GEAR

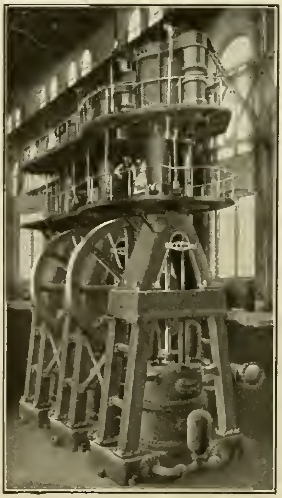
This engine is adapted for all speeds from 125 to 200 RPM. It is made from our regular Corliss patterns, with changes in the valve gears to meet the demand for higher speeds than are possible with the releasing gear and dash pots.

This engine is entirely in a class by itself and is different from the so-called "four valve engine." The valve movement is as near the regular Corliss movement as it is possible to make, without a hook and dash pot release. The mechanism is such that the valves move during the balanced period, giving highest economy and least wear. The rocker arms, etc., are as light as possible consistent with strength, reducing inertia forces to a minimum.

The valve stems are equipped with special spherical metallic packing of our own design (patented), eliminating the use of stuffing boxes. The entire valve gear sets close to the cylinder, as shown in the illustration.

The governor used on this engine is of the shaft type (patented) and is different from any other manufactured. It is arranged so that the governor weights, springs and eccentrics are in perfect gravity balance at all speeds, making it possible to equalize the steam distribution in each end of the cylinder. Another feature of importance is that the spring is attached to the weight in such a manner that its force and the centrifugal force of the weight are nearly opposite, making the resultant force and the wear on the weight pin very small indeed.

Every detail of our engines receives great care and is fully described in our bulletins issued at frequent intervals.



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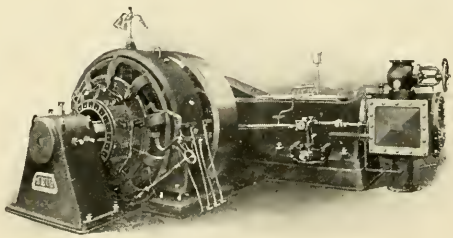
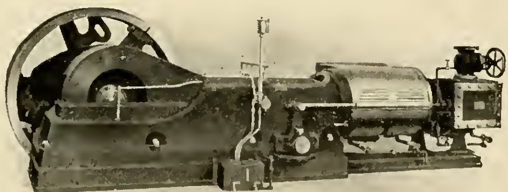


A single-valve Skinner Engine will give better economy after six months' operation than any High Speed Four-Valve.



The Skinner Double-Eccentric Compounds have established American records for economy. Two engines, tested fourteen months after starting, and without re-fitting of valves, showed the following economies, with 132 pounds steam pressure (saturated) and atmospheric exhaust

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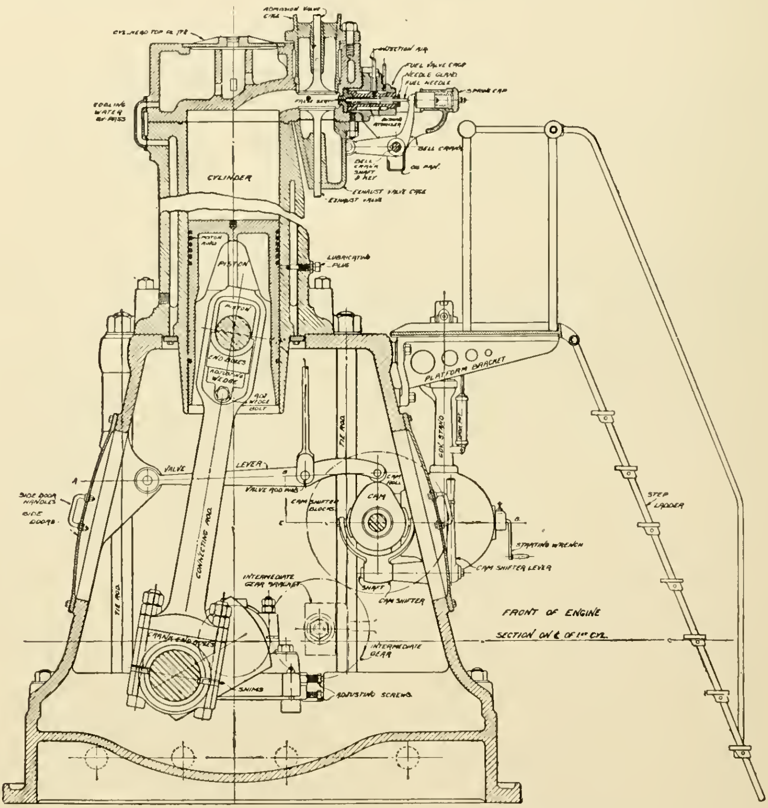

These engines are the most economical prime movers known.

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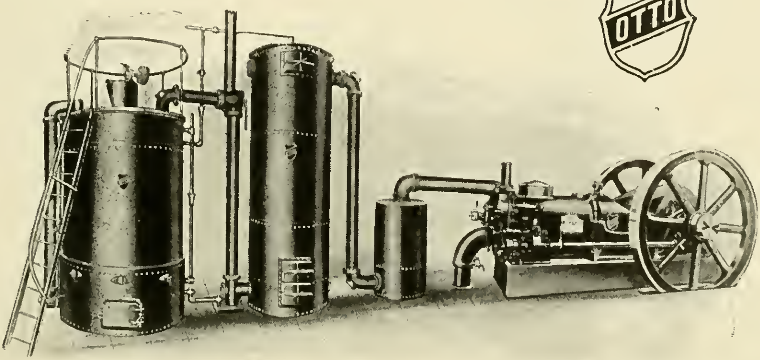

Otto Suction Gas Producer and Latest Throttling Governor Engine

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The "Otto" Suction Gas Producer converts the heat of anthracite coal, charcoal, or coke into producer gas or semi-water gas, containing a certain amount of carbon monoxide and hydrogen, and having a heating value of approximately 130 to 140 B.T.U. per cu. ft. The loss due to purifying and cooling of the gas, etc., is only about 20 per cent, so that 80 per cent of the total heating value of the fuel is available for power or heating purposes, as against about 15 to 20 per cent in the average steam plant.

The complete producer consists of three cylindrical tanks; one being the producer proper containing the fire and carrying at the top the evaporator or moistener; the second is the scrubber filled almost to the top with coke, and the third is the gas receiver which acts as a small storage tank for the finished gas.

All precautions have been taken to make "Otto" Gas Producers and Gas Engines absolutely safe and reliable and they are listed and approved by the National Board of Underwriters.

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When using coal of suitable quality the fuel consumption *is guaranteed* not to exceed 1¼ lb. per brake h. p. per hour during full load runs. Actual practice has shown considerably more favorable results, as we have records of many large plants operating on less than one lb. per h. p. hour.

"Otto" horizontal engines are built in all sizes from 4 to 300 h. p.

Bulletins No. 10 and 24 and booklets No. 6 and 8 furnish complete information. Mailed upon request.

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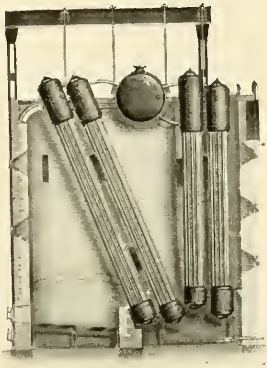


Cross Sectional View Through the Brickwork

Features of the Bigelow-Hornsby Boiler that meet the requirements of Modern Power House Practice:

Unlimited size of units.

Small ground space occupied.

Coldest water meets the coldest gases.

Direct heating surface about four times as great as the average water tube boiler.

All parts, both external and internal, readily accessible.

All boiler tubes perfectly straight.

Circulation of water and liberation of steam unrestricted.

Very dry steam, also ample room for superheaters where required.

High continuous economy due to extreme cleanliness of the most efficient heating surface.

Arrangement of baffling is unique, causing the gases to pass over the heating surface in thin streams and uniformly at every point.

Furnace arrangement is ideal for securing perfect combustion, as furnace is correctly shaped and of ample size.

Greatest flexibility, both as to construction and in steaming qualities.

No cast iron used in any portion of the boiler proper.

Constructed both as to workmanship and material in accordance with the most advanced boiler practice.

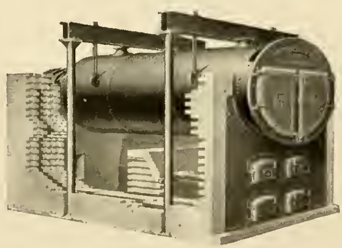
THE BIGELOW-MANNING BOILER

Standard Manning

This type of boiler can be constructed suitable for 200 pounds working pressure or more, in units up to 500 H.P. The shell sheets being away from contact with the fire permits the use of any thickness of shell necessary for high pressures. Another feature conducive to safe operation is the firm support of the boiler, which is accomplished in the Bigelow-Manning type by having a firm foundation upon which the cast iron base rests, without relying upon the support of setting walls or expensive structural work.

The economical evaporative performance of the Bigelow Manning Boiler is remarkable. All radiant heat from the fuel bed is absorbed directly by water-heating surface, the distribution of the furnace gases over the heating surface is practically uniform, the superheat furnished is varied by changing the water level, there are no losses due to the infiltration of air in the setting and stand-by losses are comparatively small, occupying per H. P. much less ground space than other types.

HORIZONTAL RETURN TUBULAR BOILER



I Beam Suspension Type of H. R. T.

The advantages of compactness and efficiency, large direct heating surface, easy cleaning, large liberating surface, perfect circulation and minimum liability and ease of repairs are well known features of this type of boiler.

Our boilers are constructed in the most approved manner; we adopt the very highest type of professional and mechanical service, endeavoring to maintain the highest possible standard of efficiency, and believe our facilities for boiler construction are without a parallel.

JOHN O'BRIEN BOILER WORKS CO.

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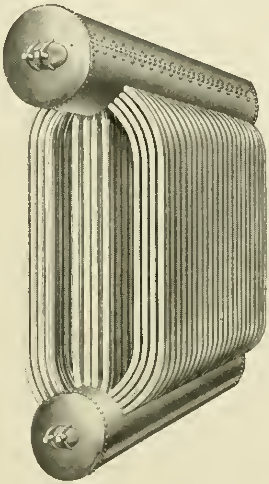
WATER TUBE AND TUBULAR BOILERS; IMPROVED O'BRIEN-HAWLEY DOWN DRAFT FURNACE.

WATER TUBE BOILERS



VERTICAL TYPE

The O'Brien Vertical Water Tube Boiler was designed to insure simplicity and durability of construction together with absolute safety and the highest obtainable economy. The complete boiler consists of but two component parts, the drums and the flues.

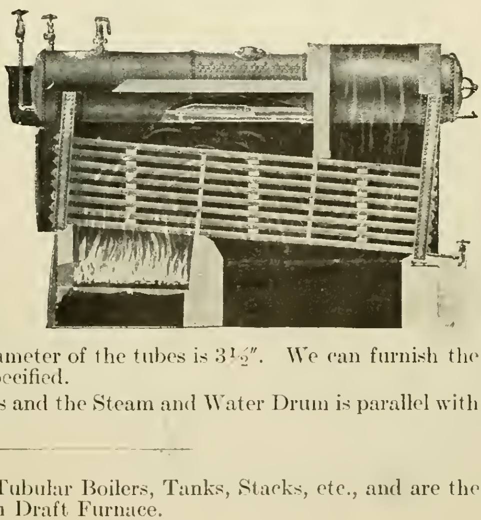
The drums are cylindrical in shape with heads dished to the proper radius to avoid bracing. The shell and heads are made of open hearth homogeneous steel of 60,000 pounds tensile strength and riveted to suit the pressure required, thickness of material considered.

The Tubes are bent to a uniform radius at either end and can be reversed from top to bottom or can be used in the corresponding row front or back. They are so spaced with sufficient area between each nest of two tubes to permit removal or replacing easily.

The boiler is suspended by the upper drum, resting in saddles supported on a substantial gallows frame of structural steel and is suspended absolutely free of the brickwork.

HORIZONTAL TYPE

Design B. Vertical Baffle



The O'Brien Horizontal Water Tube Boiler consists of one or more steam and water drums to which is securely riveted a front and rear water leg or header. The drums are perfectly level when the boiler is in position.

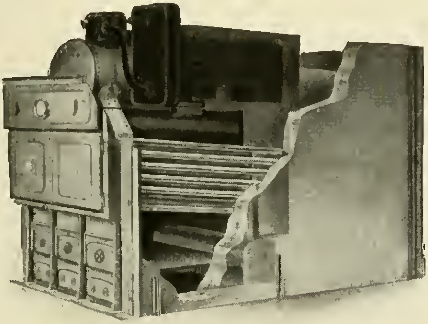
The tubes are expanded into the headers in straight horizontal and staggered vertical rows and are inclined 1″ to the foot. A greater pitch can be had if desired. The outside diameter of the tubes is $3\frac{1}{2}$″. We can furnish the 4″ outside diameter tubes if specified.

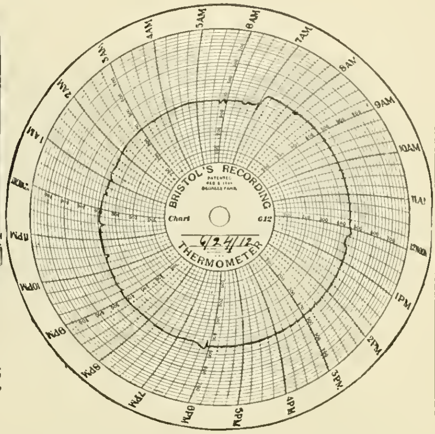
Design A has horizontal baffles and the Steam and Water Drum is parallel with the tubes.

We manufacture Horizontal Tubular Boilers, Tanks, Stacks, etc., and are the originators of the Hawley Down Draft Furnace.

HEINE SAFETY BOILER COMPANY

THE HEINE SUPERHEATER





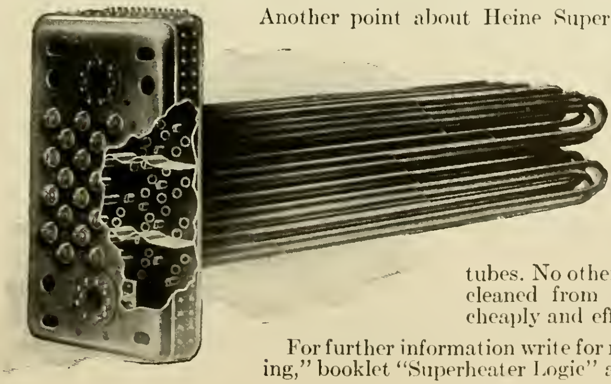
Heine boiler, equipped with a Heine Superheater; chart to right shows the close regulation of superheat temperature obtained.

The Heine Superheater may be installed on any type of boiler in new or old installations. Each unit consists of a header or box into one side of which are inserted U tubes of $1\frac{1}{2}$ inch seamless drawn mild steel tubing expanded into holes provided for them. The interior of the box is divided into three compartments and the steam makes four passes through the tubes.

Heine Superheaters are installed to the side of the boiler drum in a small superheater chamber forming a part of the main boiler setting and communicating with the furnace by a flue through which a small part of the furnace gases flow. The gases make two passes over the superheater tubes flowing out at the front, whence they pass under the boiler drum to the main uptake.

The volume of hot gases is controlled automatically or by hand by a damper in the outlet of the superheater chamber and the temperature of the superheated steam may be regulated to within 5° to 10° of any desired mean. Superheaters equipped with automatic temperature regulators will respond rapidly to any changes and constant superheat will be maintained regardless of variations of furnace temperature or load.

When the load goes off, the superheater damper closes and the superheater tubes act simply as additional steam reservoir space. Flooding of the superheater is unnecessary, with the added and important advantage that no scale-forming impurities are deposited within the tubes.



Another point about Heine Superheaters is that the header box is constructed with hollow stay-bolts, similar to the construction of Heine water legs, and therefore steam nozzles can be readily inserted for cleaning soot from the superheater tubes. No other superheater can be cleaned from soot so quickly, cheaply and effectively.

For further information write for reprint "Superheating," booklet "Superheater Logic" and other literature.

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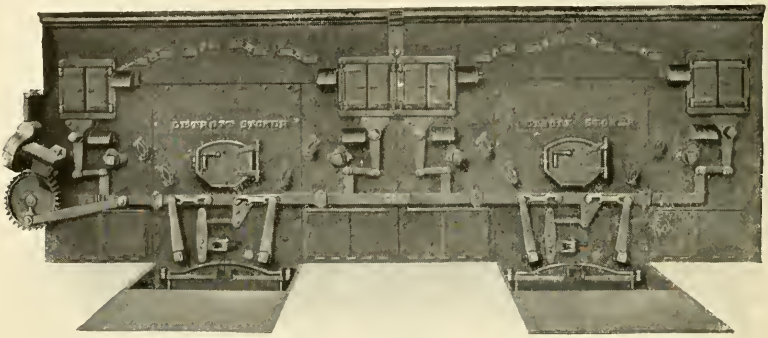
DETROIT STOKER COMPANY

DETROIT, MICH.

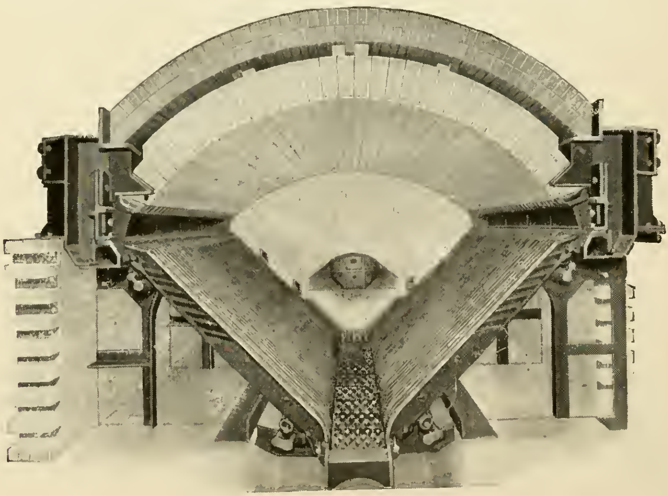
THE DETROIT STOKER



Front view of two stokers in one battery to be operated by either a fully enclosed, adjustable speed, double engine or electric motor, as preferred.

Stokers may be operated by hand when desired.

The openings through the front admit air for combustion. The even distribution of fuel on the grates insures high overload and good efficiency.



Rear view showing the double arch construction used when the stokers are installed with the extension setting. Air admitted through the front, under control, is heated between the arches and enters through openings directly over the coking coal as it is fed from the coal magazines at the upper end of the grates on both sides.

Each alternate grate is operated by links connected to the operating bar in front and have a slicing motion to keep the entire bed of fire moving towards the center of the furnace. The movement of the vibrating grates prevents the clinkers from forming on the grates.

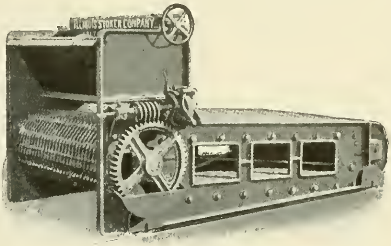
The clinker crushers at the bottom, having a continuous motion, grind the clinkers and deposit the refuse in the ashpit below.

ILLINOIS STOKER COMPANY

ALTON, ILLINOIS, U. S. A.

MANUFACTURERS OF CHAIN GRATE STOKERS

THE ILLINOIS STOKER COMPANY'S GRATE STOKER



Showing driving mechanism of Stoker

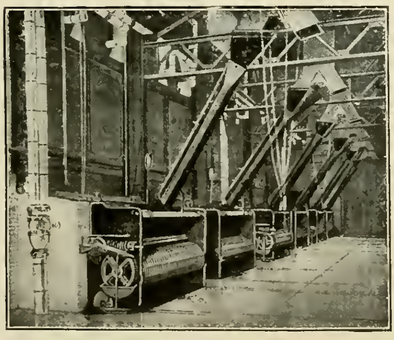
The general view of this Stoker is given in the illustration herewith. The coal is supplied to the traveling grate from the hopper, shown in the upper front part of the furnace. The grate in carrying the coal into the furnace passes under an adjustable gate which can be raised to give any desired thickness of fuel bed up to twelve inches by turning the hand wheel at the top of the Stoker. The adjustment, together with the variable speed at which it is possible to operate the grate by means of the speed adjusting lever shown on the driving mechanism, makes it possible to feed any desired number of pounds of coal per square feet of grate surface per hour into the furnace.

By controlling the thickness of the fuel bed and speed with which the coal is fed into the furnace, it is possible to obtain any desired load from the boiler with coal of either very high or very low heat value, or coal very small or coarse in size.

By raising or lowering the gate and determining the thickness of the fuel bed, which is fed into the furnace, proper allowance can be made for the burning of coal of various sizes. For example: Assuming that the draft over the fire is constant, the larger size of coal will have larger air spaces between the individual pieces of coal than a coal of smaller size, so that with a given draft more air will be forced through a coal bed six inches thick while burning the larger size of coal than will be forced through the same thickness while using coal of a smaller size. Adjustment should therefore be made in each case so as to obtain the proper amount of air through the coal for the proper burning of the particular kind of coal used.

The ease with which the gate can be lowered or raised in the Illinois Stoker makes it feasible to maintain the proper thickness of the fuel bed for each kind of coal supplied to the furnace. The exact thickness of the fuel bed is at all times indicated in inches by the gauge shown just above the handle for raising the gate.

Attention is called to the solid construction of the side frame of this Stoker, which is cast in one single piece from the front to the rear of the Stoker, so that the entire chain and driving mechanism is supported on this single solid casting. This construction is found only in the Illinois Stoker and makes it the most rigid and substantial Stoker on the market. Note the heavy ribs on all edges of the side frame.



Illinois Stokers in operation

GOOD FEATURES OF ILLINOIS STOKER

Heavy Castings throughout and Rigid Bracing. Sprockets engage on Rollers, not on rods. Evenness of chain due to close spacing of rollers. Uniform distribution of air supply through coal. Patented air baffling system in rear of grate. Large combustion space due to inclined grate. Excellent speed controls. Short Link. Minimum loss of coal through grate. Independent flat ignition arch. General appearance and mechanical design. Drums are used on the rear end instead of sprockets, hence there are no rear sprockets to cause trouble.

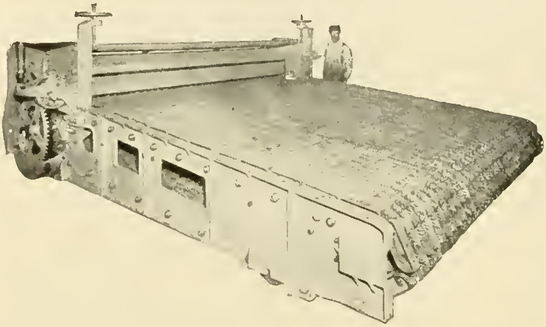
Complete illustrated catalogue mailed on request.

LACLEDE-CHRISTY CLAY PRODUCTS COMPANY

ST. LOUIS, MISSOURI

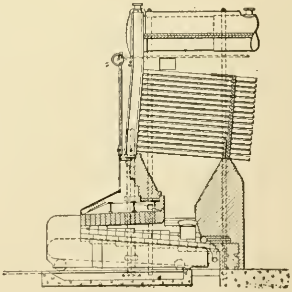
"LACLEDE-CHRISTY" CHAIN GRATE STOKERS; CLAY PRODUCTS AND REFRACTORIES; INDUSTRIAL PLANT CONSTRUCTION.

CHAIN GRATE STOKER DEPARTMENT

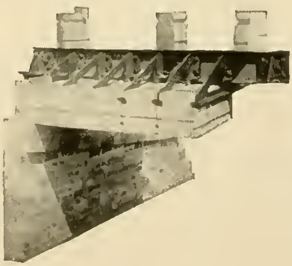


There is a striking individuality in the "Laclede-Christy" Chain Grate Stoker springing from its distinctive features. These are carried uniformly throughout the entire range of standard sizes from the smallest to those of unusually heavy pattern built for the largest of boiler units and designed for the extreme high capacities now required by modern power plant operation. Mechanically, these stokers are all that ingenuity of design, carefulness in the selection of material and watchfulness in construction can make them.

Second in importance to the mechanically perfect stoker is the arrangement and construction of the stoker's setting and surrounding brick work which forms the furnace space. Such matters as low maintenance cost, smokelessness, economy and high rates of burning are more essentially matters of the design and construction of the furnace, which features receive our special attention. Our several engineering departments, each making a specialty of an industrial furnace, supplies a wide experience in the burning of fuels. We manufacture all refractory material required in boiler and furnace settings, such as flame plates or baffle tile, boiler tube tile, special bridge wall tile, furnace blocks, and all types of ignition arch tile.



Stoker Applied to Water Tube Boiler



"Laclede-Christy" Patented Flat Suspended Arches are built in all sizes and are used extensively for ignition arches for all types of chain grate stokers, Stirling boiler arches, crowns of industrial furnaces, and all cases where service and conditions are such that radial arches are difficult to maintain. These patented arches are built of our very highest grades of refractory material, and the heavy, rigid construction of the self contained supporting structure furnishes an unusually durable construction.

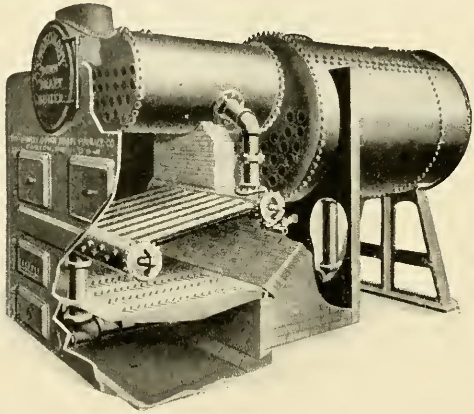
"Laclede-Christy" Hollow Stack Linings are light, durable, installed with little expense, and especially adapted for lining steel or brick stacks of large dimensions.

THE HAWLEY DOWN DRAFT FURNACE CO.

EASTON, PA.

BUILDERS OF THE HAWLEY DOWN DRAFT FURNACE AND THE HAWLEY (SCHWARTZ) METAL MELTING FURNACE.

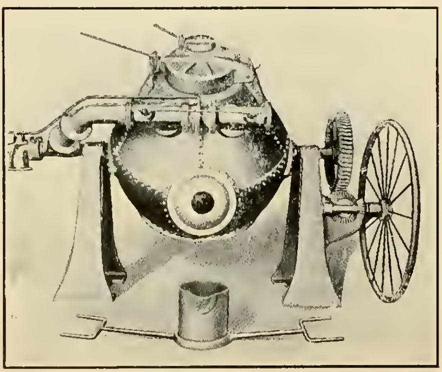
THE HAWLEY DOWN DRAFT FURNACE



The Hawley Down Draft Furnace consists of two grates: a water tube grate and a common grate. The water tube grate is piped up with the boiler and the water circulates through it and the piping. Coal is fired upon the water tube grate and the flames pass downward instead of upward as usual, and the gases, distilled from the coal by the heat, are burned as they are driven off. The common grate is placed a short distance under the water tube grate, and as the upper fire is worked, the coked fuel falls on it and a further burning takes place. Between the two, therefore, an efficient furnace of very high temperature results. It will be seen that conditions for the entire combustion of the coal are thus fully met. The heat of the gases is made available, thereby saving fuel, while heating surface is added to the boiler and its natural circulation greatly intensified. The furnace temperatures are practically uniform, as are those of the water in the boiler.

The resulting advantages may be summarized as follows: (1) Practical Smokelessness—95% of the smoke, when burning any grade of bituminous coal, being prevented; (2) Additional Capacity—25 to 50% being added to the rated output of the boiler; and (3) Saving of Fuel—coal bills being reduced from 10 to 20 per cent.

THE HAWLEY (SCHWARTZ) METAL FURNACE



An improved device, using oil or gas for melting, refining or reducing steel, semi-steel, grey iron, brass, bronze, copper, aluminum, etc.

Its use affords economy in space, labor, fuel and melting, and such savings have given it a well defined position in the metal industry. This furnace possesses advantages over crucible process and those interested should have our special catalogue which gives valuable technical information. The furnace is made regularly in the following sizes: 22″, 32″, 42″, 60″, 75″ and 90″.

POWER SPECIALTY COMPANY

111 BROADWAY, NEW YORK, N. Y.

Boston Philadelphia Chicago Pittsburg Birmingham San Francisco

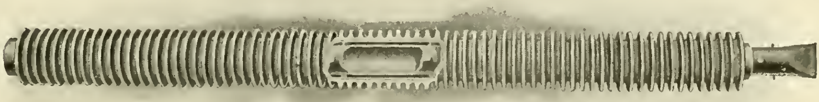
FOSTER SUPERHEATERS; DUVAL METALLIC PACKING; SUPERHEATED STEAM BRONZE GASKETS, HEENAN MUNICIPAL REFUSE DESTRUCTORS.

THE FOSTER PATENT SUPERHEATER

The Foster Superheater is made for every class of service, either combined with boilers or separately, in four general types, as follows: (1) Attached Type for superheating up to 200 deg. Fahr., (2) Separately Fired Type for any range of superheat up to 1200 deg. Fahr., (3) Waste-Heat Type for steel and fabric mills or marine practice and (4) Portable Type for heating steam or air with oil, coal or gas fires.

CONSTRUCTION

Those features of construction which distinguish the Foster Superheater from all other types are chiefly the result of actual experience in designing and building superheaters.



Sectional View of Foster Superheater Element

The Foster Superheater consists of a series of straight elements or tubes which are generally placed parallel to each other. The elements are joined at one end to manifolds or connecting headers, and at the other end to return headers, for which return bends are often substituted. The elements consist of straight seamless drawn steel tubes, on the outside of which are fitted a series of cast iron annular gills or flanges, placed close to each other and carefully shrunk on to the tube so as to be practically integral with it, at the same time exposing an external surface of cast iron, which metal is best adapted to resist the action of the hot gases. This form of construction is flexible and durable, providing a section of great ultimate strength and entire freedom from internal strains. The mass of metal in the tubes and covering acts as a reservoir for heat, which is imparted to the steam evenly, tending to secure a constant temperature of steam in spite of fluctuations in the temperature of the hot gases.

Inside of the elements there are placed other tubes of wrought iron, closed at each end, which are centrally supported by means of knobs regularly spaced throughout their length. A thin annular passage for the steam is thus formed between the inner and outer tubes. The steam clinging closely to the heating surface is quickly and efficiently heated.

The joints at the ends of the elements are made by expanding the steel tube into headers which are of wrought steel.

The resulting advantages of the above features are thus summarized: PERFECT STEAM CIRCULATION, ANY DESIRED TEMPERATURE, UNIFORM SUPERHEAT AND FREEDOM FROM REPAIRS.

DUVAL METALLIC PACKING

is extensively used for superheated and saturated steam, also for steel or iron plungers where working in water or oil, in pumps or accumulators, for heavy pressures from 500 to 2500 pounds per square inch of pressure. No special form of stuffing box is required. The packing is flexible, made of fine quality wire plaited into square forms, and is easily cut with wood chisel. It is adopted in the French, British and American Navies.

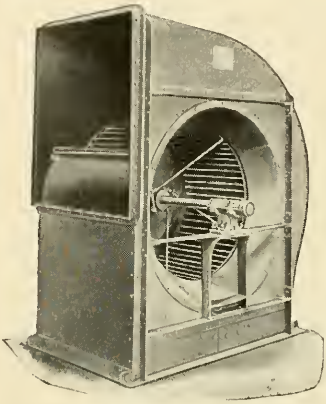
SUPERHEATED STEAM BRONZE GASKETS

give excellent satisfaction in flanged joints of pipes conveying superheated steam. They are corrugated evenly with sharp ridges. The metal is well suited to high temperatures and has elastic properties tending to maintain tight joints.

AMERICAN BLOWER COMPANY

DETROIT, MICH.

MANUFACTURERS OF HEATING, VENTILATING, DRYING, MECHANICAL DRAFT AND BLAST EQUIPMENT: VERTICAL SELF-OILING STEAM ENGINES, STEAM TRAPS: FANS AND BLOWERS FOR ALL PURPOSES.



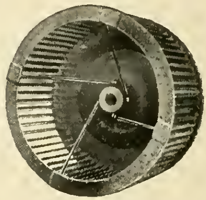
Right Hand, Top Horizontal Discharge, Pulley Driven Sirocco Fan.

"SIROCCO" FANS AND BLOWERS

The reason why "Sirocco" Fans and Blowers are used in the world's largest Industrial, Educational, Office and Public Buildings, — *A "Sirocco" Fan will deliver more air, consuming less power than an ordinary steel plate fan twice the size.*

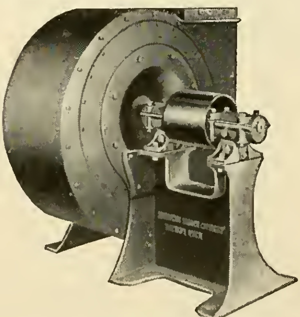
"Sirocco" Fans are built in sizes with capacities from 75 CFM to 1,000,000 CFM.

"Sirocco" Fans cost less to instal on account of their *small size,* less to operate because of their high *mechanical efficiency,* less to maintain because of their *sound construction* and *perfect balance.*



"Sirocco" Fan Wheel or Runner.

Complete information—capacity tables, etc., in Bulletin No. 340.



Type "E" Right Hand, Top Vertical Discharge, Pulley Driven Fan, built also for motor drive.

"ABC" TYPE "E" EXHAUST FANS FOR EXHAUSTING AND CONVEYING SYSTEMS

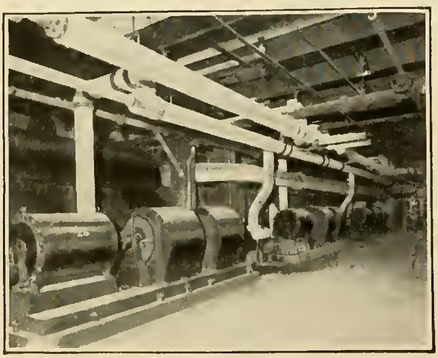
Every wheel is perfectly balanced before mounting.

The entire construction of "ABC" Exhaust Fans provide for strength and rigidity. The bearings are self-aligning, long and of large diameter, giving ample bearing surface.

Type "E" Fans are interchangeable, can be arranged to deliver air at almost any angle by merely removing bolts from ring plates.

Regular type "E" wheels are used in Fans for removing dust from emery wheels, sawdust, etc. Long shavings wheels are used in Fans for work in Cooperage and Excelsior factories, wood pulp mills or other plants where the shavings are long and stringy, lint from buffing and polishing wheels, etc.

Bulletin No. 323 gives capacity tables, etc.



"Sirocco" Turbine Driven Mechanical Draft Fans, supplying forced draft to two 2365 horsepower boilers, the largest in the world.

"SIROCCO" MECHANICAL DRAFT FOR STEAM BOILERS

A boiler plant will do more work with "mine run" coal and a "Sirocco" mechanical draft fan than it will with *high* grade coal without "Sirocco," *because* of the increased and improved combustion, more thorough utilization of waste gases, absolute independence of atmospheric conditions and practically absolute control of the fires.

A "Sirocco" mechanical draft plant, either of the Forced or Induced Type requires small space for its installation, as compared to its capacity. Two of the largest boilers in the world are equipped with "Sirocco" mechanical draft fans.

Catalogue No. 343 is a complete treatise on mechanical draft.

AMERICAN BLOWER COMPANY

Branch Offices in New York, Chicago, Philadelphia, Pittsburg, Rochester, Atlanta, Minneapolis, San Francisco, Los Angeles, Seattle and Portland, Ore., with works at Troy, N. Y. and Canadian Sirocco Company, Limited, Windsor, Ontario.

"ABC" VERTICAL ENCLOSED SELF-OILING STEAM ENGINES

"ABC" Engines are built in two general types—Type "A," Single Cylinder and Type "E," Double Cylinder, with capacities up to and including 120 horse power, are used extensively to drive electric generators, exciter units, centrifugal and all kinds of power pumps, paper mill machines, centrifugal dryers, in fact for any purpose requiring a good dependable engine; unexcelled for any auxiliary work within their capacity.

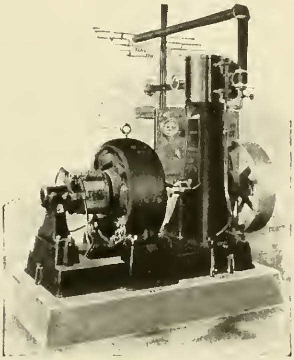
"ABC" engines will run from three months to two years without having to add new oil to original supply or make an adjustment.

Are entirely enclosed, but a turn of a nurled knob will remove side plates, rendering every piece of mechanism accessible.

"ABC" Engines are oiled automatically—by themselves, no oil leaks out of the frame; it is not a splash system, every drop goes to its proper place by gravity, and is supplied as required. *Every frictional surface runs on a film of oil, no contact between metals.*

Oil is filtered and cooled before being pumped up for recirculation.

Engine Bulletin No. 334 contains specifications, description, etc.



"ABC" Engine direct-connected to dynamo for generating electric current.

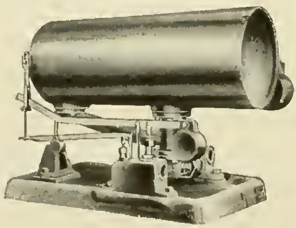
"DETROIT" AUTOMATIC STEAM TRAPS—RETURN, SEPARATING AND VACUUM

Return Traps save the most valuable part of condensation—*its heat*—by draining steam lines of the condensation and automatically returning it to the boiler *hot.*

Separating Traps are adapted to draining oil and steam separators, bleeding high and low-pressure cylinders in compound engine installations, etc.

Vacuum Traps are most successfully used to remove condensation from apparatus, or systems working under a vacuum.

Trap Catalogue No. 352 gives complete information about "Detroit" Traps.



"Detroit" Automatic Return Trap.

HEATING, VENTILATING AND COOLING WITH A "SIROCCO" FAN SYSTEM

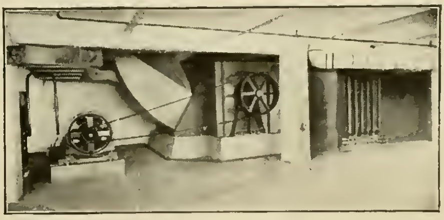
Requires only a small space for its intallation to handle immense volumes of air, because of the small size of the fan.

"Sirocco" Fans can be installed in confined spaces which would absolutely preclude the use of any other type.

The sound construction and perfect balance of "Sirocco" Fans keep the cost of maintainence down to a minimum.

The power conserving features of "Sirocco" Fans is derived from their unique design, having a large and practically unobstructed inlet, employing blades which are short radially and very long axially.

The "Sirocco" Fan System of Heating, Ventilating and Cooling makes neat, compact and efficient equipment.



"Sirocco" Fan System of Heating, Ventilating and Cooling, installed conveniently in a very low ceiling basement. No excavation for head room necessary.

THE GREEN FUEL ECONOMIZER CO.

MATTEAWAN, N. Y.

New York City Boston Chicago Atlanta San Francisco
Los Angeles Seattle Salt Lake City Montreal

FUEL ECONOMIZERS for recovering waste heat from boiler furnaces, kilns, soaking pits, metallurgical furnaces, core ovens, gas engines, etc., to heat water for boiler feeding and other purposes.
WASTE AIR HEATERS, Similar to the Economizer and utilizing heat from the same sources to heat air for the heating of buildings, or for drying purposes, regenerative furnaces, etc.
FANS, BLOWERS and EXHAUSTERS for ventilating and for moving air for all purposes.
ENGINES, horizontal and vertical, throttling or automatic, for driving fans.
POSITIVFLOW HOT BLAST HEATERS, for live or exhaust steam or hot water.
DRYING EQUIPMENTS for all kinds of material.
HEATING AND VENTILATING EQUIPMENTS.
MECHANICAL DRAFT INSTALLATIONS.

GREEN'S FUEL ECONOMIZER

Green's Fuel Economizer is the counter-current or multi-stage principle applied to steam generation. The boiler is required for absorbing from the gases of combustion the heat required for evaporation, and to provide for the separation of the steam from the water, but the boiler surface should not extend beyond the point where the heat absorbed per square foot is worth less than the annual charges and upkeep upon that square foot. The rate of heat absorption decreases as the temperature of the gases decreases, and this point is found at gas temperatures between 550 and 700° F., according to the price of coal and other variables. To extend the boiler surface beyond this point is wasteful, since it will not repay fixed charges, and if an economizer is used, the boiler can to advantage be terminated before this point.

Green's Economizer With Sectional Covering

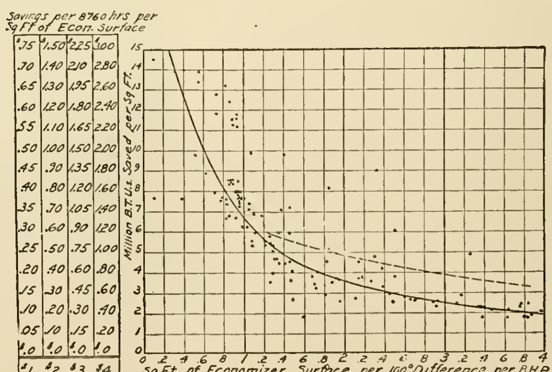
The Economizer, however, absorbs heat economically from fuel gases at temperatures down to 300° F., primarily because it contains cold water, giving a greater "temperature head" than in the case of the boiler surface, also because it costs less, square foot for square foot, and is subject to a lower annual percentage charge for upkeep and depreciation than is the boiler surface.

As ordinarily installed, the Economizer reduces the flue gas temperatures from 600° F. to 300° F., saving 1% of fuel for each 20° reduction in the flue gas temperature. The Economizer repays from 40 to 60% interest upon the investment annually.

Example

Plant to operate 12 hours per day, 365 days per year; temperature of gases leaving boiler, 600°; Temperature of cold boiler feed water, 100° F.; Coal at $3.00 per ton; Each square foot of the Economizer to earn 50 cents per year. Find sq. ft. of Economizer to be installed per boiler H.P.

If the Economizer operates only half the time, it must earn at



THE GREEN FUEL ECONOMIZER CO.

twice the rate of 50 cents per year while in operation; therefore in the column for \$3.00 coal find \$1.00, run horizontally to the curve, which is encountered at 1 sq. ft. per 100° F. difference between hot gases and cold water. As in this example the difference is 400°, four square feet will be the right amount of Economizer surface to install per boiler horse power developed in order to secure an annual profit of 50 cents per square foot.

Construction of Economizer

Green's Economizer, as perfected by 60 years' experience, consists of vertical cast iron pipes about 9 ft. long, pressed with metal to metal joints into top and bottom boxes to form sections, which are assembled side by side to make the complete Economizer. The sections communicate through flexible joints placed outside the Economizer chamber with two branch pipes, one running lengthwise at the bottom and the other at the diagonally opposite upper corner, the water being introduced into the former and discharged from the latter. The pipes are cast of a special grade of iron in vertical dry sand molds, and are tested to 500 lbs. pressure per square inch. The top boxes are planed on the sides and fitted together to make a gas tight joint, rendering other covering unnecessary. Our patented ovoid bottom box is so constructed as to leave large passages between for convenience in replacing scrapers, and also to prevent the bridging of soot across from one box to another. When installed with Green's Sectional Covering, the Economizer is readily accessible in all parts.

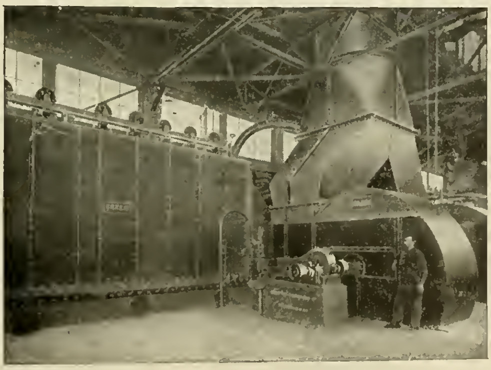
Dimensions

Height from bottom of sections to top of scraper gearing 13 ft. 5½ ins. Height over sections, 10 ft. 2½ ins. based on 9 ft. pipes; 10 ft. pipes and other lengths are special. Each section occupies 7½ ins. of the length of the Economizer.

Widths: Four pipe sections, 3 ft. 4 ins.; six pipe sections, 4 ft. 8 ins.; eight pipe sections, 6 ft.; 10 pipe sections, 7 ft. 4 ins.; twelve pipe sections, 8 ft. 8 ins. For one side damper add 9 inches, for two, add 18 inches. Diameter of pipes, 4 inches. Square feet of heating surface per pipe, 12.

GREEN'S MECHANICAL DRAFT OUTFITS

In many cases it is more economical to provide a fan and engine to produce draft than to depend upon the chimney, especially as the heat required to produce draft in a chimney can better be employed in warming feed water in an Economizer.



Mechanical draft is also useful in increasing the capacity of boilers, enabling the boilers to carry temporary overloads, making possible control of fires in all conditions of wind and weather, enabling the plant to use a cheaper grade of coal, etc. Green's Induced Draft Fans are constructed of especially heavy steel plate, and the wheels are thoroughly well made, the floats or vanes being attached to the side plates by angle irons instead of by turning up the ends of the blade and riveting. The wheel is also stiffened by angle iron rings at the inner and outer edges of the side plates, also by special stiffening rings on the spokes in the case of large wheels. We have built a large number of mechanical draft wheels 18 ft. in diameter and 8 feet wide and larger.

Where chimneys are already installed, Green's Forced Draft Outfits will make possible a great increase in boiler capacity without the necessity of additional or higher chimneys.

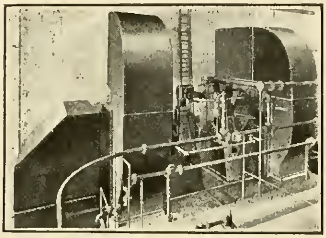
B. F. STURTEVANT COMPANY

HYDE PARK, BOSTON, MASS.

Offices in all principal Cities

MECHANICAL DRAFT, FUEL ECONOMIZERS, STEAM TURBINES, STEAM ENGINES, GASOLENE ENGINES, GASOLENE ENGINE GENERATING SETS, MOTORS, GENERATORS, STEAM TRAPS, HEATING AND VENTILATING SYSTEMS, FANS, BLOWERS, EXHAUSTERS, ETC.

MECHANICAL DRAFT



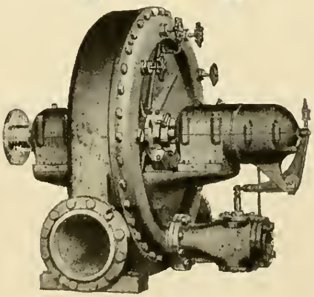
Draft produced by a fan is called mechanical draft, and may be forced or induced as conditions demand. Its cost is from 20 to 40 per cent of that of a chimney. Its intensity permits of the burning of finely divided or low grade fuel. It makes possible the utilization of the flue gases which a chimney wastes in producing draft, it is independent of the weather, decreases smoke, increases the capacity of an existing plant, and serves as an auxiliary to a chimney already overburdened. It saves space and is portable.

FUEL ECONOMIZERS

The Sturtevant Economizer effects:
A saving of 10 to 20 per cent in fuel,
An increase of 20 to 40 per cent in boiler capacity,
An appreciable extension of the life of a boiler,
A purification of the feed water,
A reduction in expense of repairs,
The deposit of large amounts of soot.

In the Sturtevant Economizer the pipes are arranged "staggered" instead of in straight rows, thereby giving the pipes a better opportunity to absorb heat from the gases. These economizers are made with taper metal-to-metal joints that require no packing, cement or rusting. The placing of the pipes of one row opposite the spaces of the adjacent sections increases the effective area of the transmitting surfaces and thoroughly breaks up the currents of hot gases by directing them between the pipes and against those standing in their paths.

STEAM TURBINES

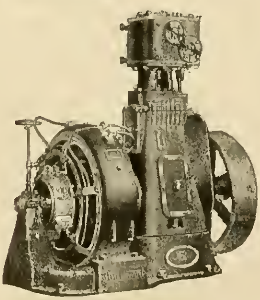


The Sturtevant Steam Turbine is of the multi-velocity type, and its operation is such as to give high efficiency, and permit of moderate rotative speeds without gears. Hand valves are used for shutting off the nozzles, and the speed is regulated by a centrifugal throttling governor placed on the end of the shaft.

No special foundations are required and the turbine can be placed on an ordinary floor. Internal lubrication is unnecessary, therefore the exhaust steam is free from oil.

5 regular sizes from 5 to 250 H.P.
Approximate speed from 4000 to 1000 R.P.M.

STEAM ENGINES
(Automatic High Speed)



Vertical Single Cylinder from 5 to 87 H.P.
Vertical Compound from 35 to 171 H.P.
Horizontal Center Crank Engine from 39 to 225 H.P.

Sturtevant Engines are adapted to continuous operation for long periods without attention. Gravity lubrication and complete enclosure of moving parts insure cleanliness and high mechanical efficiency. Rites Governor gives 1½ per cent speed variation only.

MOTORS, GENERATORS AND GENERATOR SETS
Direct Current Apparatus for any Standard Voltage

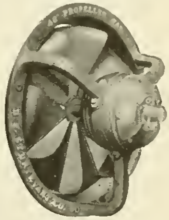
Bi-Pole Motors (enclosed and semi-enclosed type)	¼	to	3 H. P.
Four-Pole Motors	2	to	30 H. P.
Eight-Pole Motors	1	to	225 H. P.
Six-Pole Generators	5	to	17½ K. W.
Eight-Pole Generators	20	to	150 K. W.
Turbine Generating Sets	3	to	50 K. W.
Steam-Engine Generating Sets	5	to	150 K. W.

B. F. STURTEVANT COMPANY

STEAM TRAPS

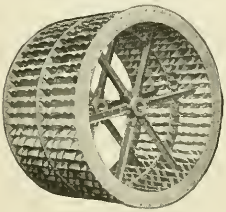
This steam trap, made for different pressures, is designed for steam heaters or radiators of any construction. Both extension and cone are of brass ground to a fit. The pot is readily removed for cleaning by loosening up the bolts.

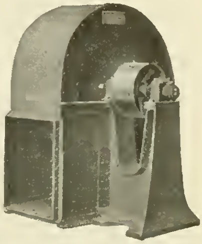
PROPELLER FANS



Propeller fans are designed for use against low pressures, and are applicable for ventilation and exhauster work in boiler and engine rooms, kitchens, clubrooms, smoking rooms, offices, stores and similar places. They are constructed with a frame of cast iron, that is fastened into the wall of the building and are driven by either belt or direct-connected electric motors that are enclosed and dust-proof. The construction of these propeller fans is exceptionally strong and durable. Propeller fans are made in sizes of from 18 to 120 inches in diameter.

MULTIVANE FANS





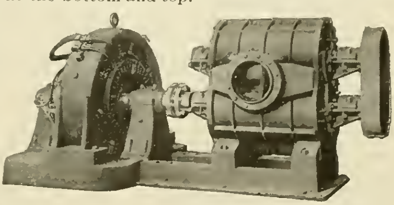
Multivane blowers and exhausters driven by direct-connected Sturtevant motors, turbines, and engines form the most satisfactory and efficient fan sets on the market. The blast wheel or runner for this fan is composed of shallow floats, which permit the use of very large inlets while maintaining the necessary blade area. The large inlet allows the air to enter with the least loss in friction. Each blade or float is spooned to distribute equally the pressure within the casing and to add rigidity and strength to the wheel.

STEEL PLATE FANS

Sturtevant steel plate fans are designed for all sorts of blower and exhauster work. They are the result of fifty years' experience in blower design, are especially strong and durable and are suitable for direct-connected steam engine and electric motor drive and for belt drive. Steel plate fans are built for ventilation and mechanical draft installations, and for planing mill and other exhauster work.

BLOWERS AND EXHAUSTERS

The Sturtevant High Pressure Blower is made in two types; in the smaller sizes the idler is directly above the impeller, and the shafts lie in a vertical plane. In the larger sizes, the shafts are in a horizontal plane, the intake and discharge being at the bottom and top.



High Pressure Blowers are designed to deliver air at pressures up to five pounds. They are especially adapted to furnishing blast for cupolas, gas and oil burners, annealing and smelting furnaces, cement kilns, and for all sorts of blower or exhauster work demanding high pressures. Special stuffing-boxes to prevent leakage are furnished when these blowers are used to handle gases.

The B. F. Sturtevant Company makes complete installations, including direct-connected, belted, or geared engine or motor, exhauster, automatic regulator, blast gates, by-pass connections, and valves.

STURTEVANT HEATERS

The Sturtevant fan system of heating and ventilating is economical and positive, heated air providing ventilation as well as heat. Indirect hot blast coils are built of one inch extra heavy steel pipe screwed into cast iron sectional heater bases. Entire heater is enclosed in steel plate casing. Heater is applicable to use of either live or exhaust steam or hot water. System can be used for heating and ventilating any sort of building. The operation is independent of the weather or of atmospheric conditions. By the use of the Sturtevant air washer, the air may be washed at all times, and cooled in summer. Hot air from the heater is forced by a fan through ducts into the building to be heated, and is allowed to escape through vent flues. Fans are driven by steam engine, motor or belt. The steam engine exhaust is used in the heater, thus eliminating the expense of running the engine. Temperature of air entering each room may be closely regulated by thermostatic control.

BAYER STEAM SOOT BLOWER CO.

For Vertically Baffled Boilers

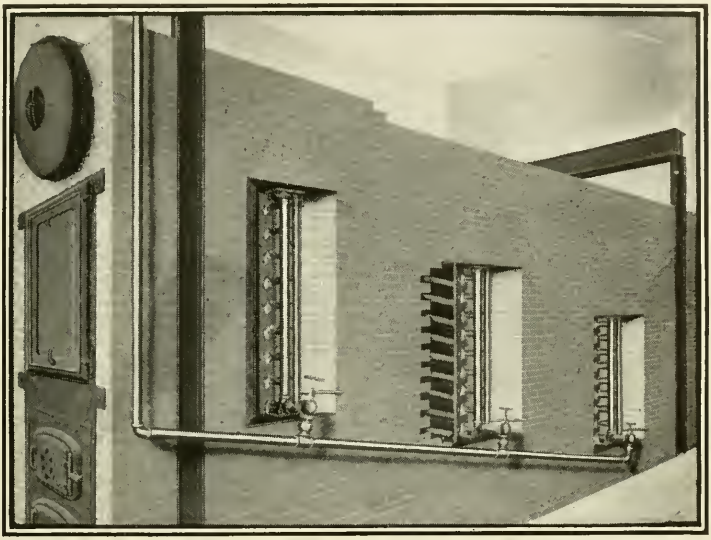


Fig. 1—Type "B" as installed on B & W Type Water Tube Boilers

In bringing our B & W Type Soot Blower to its present stage of perfection, we realized the importance of producing a device that could be installed without making any alterations in the boiler-settings, and this we have accomplished so perfectly that not a single brick need be disturbed nor any alterations made, as is plainly shown in the accompanying illustration.

Fig. three (3) is a perspective view of a single unit of the System as installed in one of the cleaning openings, and shows the simplicity and ease with which the apparatus can be attached to any vertically baffled boiler having side cleaning openings. The units of the Bayer System are secured to the plates at the top and bottom of the openings in the walls by substantial set screws (see Fig. 3), permitting the Blower to be quickly, accurately and securely adjusted to its proper position even while boilers are in service. The nozzles which always blow parallel between spaces of the water tubes are three-way cast iron nozzles. These nozzles extend through the cleaning openings flush with the inside of the boiler wall, thereby preventing them from being exposed to the direct path of the products of combustion.

To operate the Blower, move the handle of the rock shaft forward and backward slowly; this operation causes the nozzles to blow perfectly parallel with the spaces between the water tubes and reach all of the soot surface in each gas-pass or compartment. Any Blower which does not project the steam jets parallel with the spaces between the tubes with a sweeping movement cannot give perfect service.

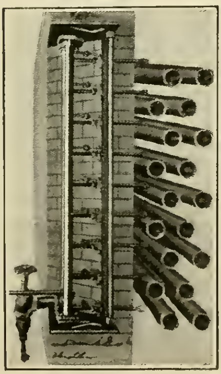


Fig. 2

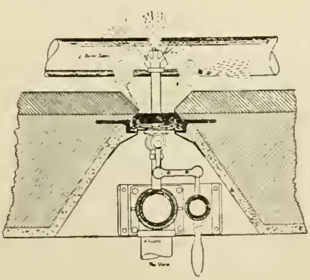


Fig. 4
Top View Showing Sweep of Nozzles

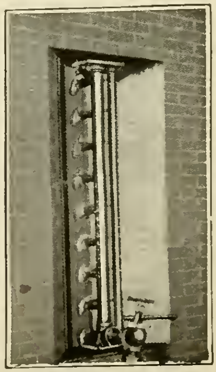


Fig 3

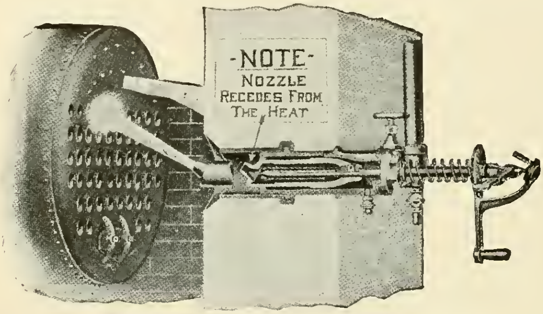
DIAMOND POWER SPECIALTY CO.

Main Office and Factory

DETROIT 70 FIRST STREET MICHIGAN

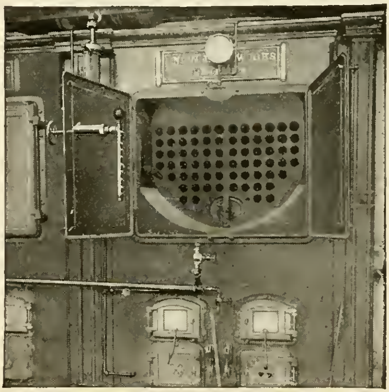
SOOT BLOWERS FOR ALL STANDARD BOILERS

DIAMOND SOOT BLOWING SYSTEMS



1. Rear-End Design—For Return Tubular Boilers

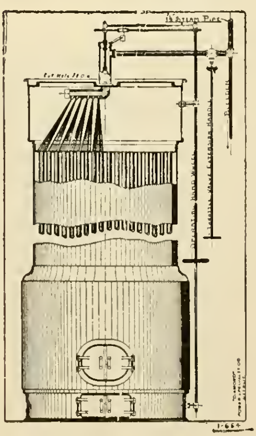
Diamond Power Specialty Co. Soot Blowers for all standard boilers have been developed through 15 years of experience in this field. These Diamond Soot Blowing Systems are permanently attached to the boiler — enabling the engineer to keep his heating surfaces free from soot at all times, by a simple mechanical steam-scouring action.



2. Front-End Design—For Return Tubular Boilers

OVERCOMING SOOT

The wasteful action of soot deposits —both in lost heat and in boiler depreciation—make necessary a positive method of overcoming this. In meeting this need these Soot Blowers produce an important economy in the plant.



3. For "Manning" Boilers

CLEANING FIRE TUBE BOILERS

Horizontal Return Tubular Boilers are cleaned from either rear or front end. The "Diamond," "Single Telescopic Jet" (see Fig. 1), "Swinging Arm," and "Revolving 5-Hole" Designs—are Rear End Designs. Fig. 2 shows the "Front End" Blower—open for inspection.

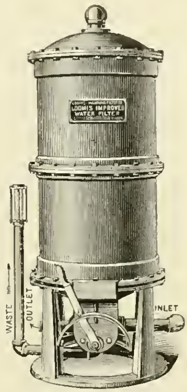
Vertical Fire Tube Boilers—"Manning" Type—are cleaned from top as shown in Fig. 3. Either "Swinging Arm" or "Revolving 5-Hole" designs are applied here.

LOOMIS-MANNING FILTER DISTRIBUTING COMPANY

PHILADELPHIA, PA.

Branch Offices:
New York, Chicago, Boston, Buffalo, Baltimore, Washington

Loomis-Manning Filters are designed with three essential features in view:

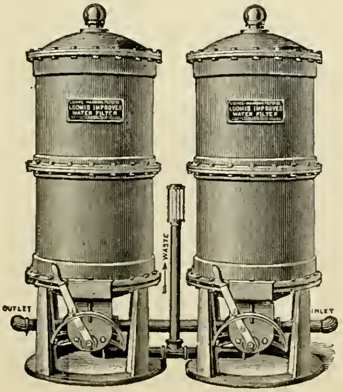


Efficiency: This, in a filter, means the ability to thoroughly cleanse the filter bed each time it is washed. For unless the filter bed is kept broken up, free from lumps of all kinds which form around the gelatinous mass which has been collected by the filter bed, the effectiveness of the filter will become less and less until it is nothing. By the reverse flow of the water, the filter bed of a Loomis-Manning Filter is caused to pass up and down through the Loomis Cutting Plate which breaks up the mass of accumulated impurities so that they are purged from the bed and carried off into the waste. The entire bed is in motion, becoming cleansed, at each washing. No part of it is so heavy that it lies stagnant. The bed is a uniform grade of material from top to bottom.

Simplicity: The Manning Single Controlling Valve takes the place of five gate valves and also prevents all chance of errors. By moving one lever to four stations, plainly marked on a dial, the action of the filter may be either filtering, washing the filter bed, filtering to waste (sometimes called re-washing) or the filter may be by-passed. A sight glass is provided so that it is possible to see the quality of the filtered water and watch the cleansing of the filter bed, preventing an extravagant use of water for washing.

Durability: The cylinders and heads are close grained cast iron, to obtain the maximum durability. All materials coming into contact with water are selected to resist corrosive action. Bronze controlling valve, tinned copper screen plates, brass studs, galvanized iron or brass pipe and fittings, etc., reduce repairs to a minimum.

Essential Details: The filter bed rests on tinned copper screen plates, extending under its entire area, bringing about a uniform collection of the filtered water and a uniform distribution of the washing water, insuring a thorough cleansing. The Loomis Confining Plate extends across the filtering chamber near the top and prevents all fish, sticks, stones, etc., from entering and becoming a permanent part of the filter bed. These screen plates are sand tight, preventing any loss of the filtering material into pipe lines, pumps etc. Baffles are provided in the top and bottom heads to distribute the water as it enters for filtration or for washing. Ample space is provided to enable the bed to wash properly. The coagulant, if necessary, is fed by our indirect method, accurately controlled.



Send for List of Installations.

BUILDERS IRON FOUNDRY

PROVIDENCE, R. I.

VENTURI METERS FOR COLD WATER, HOT WATER, BRINE, CHEMICAL SOLUTIONS, SEWAGE, STEAM, GAS AND AIR; GLOBE SPECIAL CASTINGS FOR WATER WORKS; GRINDING MACHINERY; POLISHING MACHINERY.

THE VENTURI METER

The Venturi Meter consists of a Venturi Meter Tube and a Register or Recording Instrument. The Meter Tube is set in the pipe line similar to a section of pipe, and the instrument, which is connected to the Meter Tube by two small pipes, can be set in any convenient space where the readings may be easily observed. An historical sketch of the Venturi Meter is given in Bulletin No. 20.

THE VENTURI COLD WATER METER

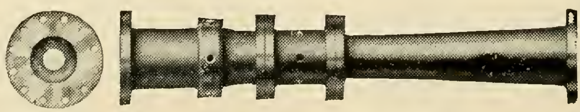
This is a type which may be used in connection with Gravity Mains, Pump Discharge Lines, Filtration Plants, Sewage Disposal Systems, Hydraulic Turbines, Refrigerating Plants, etc. Our Bulletin No. 75 contains descriptions, illustrations, tables of capacities and other data.

STANDARD VENTURI METER TUBES AND CORRESPONDING MEASURING CAPACITIES

Inches Diameter of Pipe	Catalog Number	Length of Meter Tube	Pounds per Hour		Gallons per Minute		Gallons per 24 Hours	
			Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
2	2⅝	1′-11⅞″	1360	17600	3	35	4000	51000
	2¾	1′-10¼″	1960	25400	4	55	6000	73000
	21	1′- 7″	3470	45100	7	90	10000	130000
3	31	2′-11″	3470	45100	7	90	10000	130000
	31¼	2′- 7¾″	5420	70400	11	140	16000	203000
	31½	2′- 4½″	7820	102000	16	205	23000	293000
4	41¼	4′- 3¾″	5420	70400	11	140	16000	203000
	41⅝	3′-10⅞″	9170	119000	18	240	26000	343000
	42	3′- 6″	13900	181000	28	360	40000	520000
5	51⅝	5′- 1⅜″	9170	119000	18	240	26000	343000
	52	4′- 8½″	13900	181000	28	360	40000	520000
	52½	4′- 2″	21700	282000	44	565	63000	813000
6	62	5′-11″	13900	181000	28	360	40000	520000
	62½	5′- 4½″	21700	282000	44	565	63000	813000
	63	4′-10″	31300	406000	63	810	90000	1170000
12	124	11′- 0″	55600	722000	110	1440	160000	2080000
	125	9′-11″	86900	1129000	175	2260	250000	3250000
	126	8′-10″	125000	1626000	250	3250	360000	4680000
24	248	21′- 2″			445	5780	640000	8320000
	2410	19′- 0″			695	9020	1000000	13000000
	2412	16′-10″			1000	13000	1440000	18720000
36	3612	31′- 4″			1000	13000	1440000	18720000
	3615	28′- 1″			1560	20300	2250000	29250000
	3618	24′-10″			2250	29300	3240000	42120000
48	4816	41′- 6″			1780	23100	2560000	33280000
	4820	37′- 2″			2780	36100	4000000	52000000
	4824	32′-10″			4000	52000	5760000	74880000

Dimensions of other sizes on application.

THE VENTURI HOT WATER METER



This meter, the tube of which is illustrated, is admirably adapted to the measurement of hot boiler feed water, hot water from condensers, hot circulating water for heating systems, etc. The entire absence of mechanism or projections within the Venturi Tube gives the Venturi great advantages over various types of mechanical or flow meters, and its initial accuracy, which is guaranteed, remains unchanged in actual service. It is fully described in Bulletin No. 68.

THE VENTURI AIR, STEAM AND GAS METER

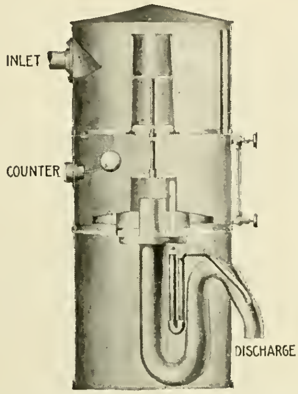
For the measurement of Air, Gas and Steam the Venturi offers distinct advantages, among which are Simplicity, Compactness, Adaptability to Changes in Measuring Capacity and Low Cost. Bulletin No. 76 describes the Meter for Air and Gas and Bulletin No. 79 for Steam.

Any or all of the above Bulletins will be mailed on request.

WILLCOX ENGINEERING CO., Inc.

SAGINAW, MICHIGAN, U. S. A.

THE WILLCOX WATER WEIGHER



Vertical Section of Portable Weigher for evaporative and condensation tests Style B

The Willcox Water Weigher is a device for **automatically weighing and recording** the water fed to boilers. It takes water from any source, such as a feed water heater, tank, pump, or hydrant, at any rate of flow or at varying rates, and delivers it intermittently in charges of uniform weight.

It will weigh hot feed water from an open heater, cold water from a hydrant, water of condensation from vacuum pans or heating systems; also chemicals, volatile oils, sugar juices, etc.

Operation: The charge is weighed by a liquid column of fixed height, through the medium of an air balance. The unit charge is dumped automatically by the sudden release of the entrapped air—an extremely accurate method of balancing.

Accuracy: Each weigher is guaranteed to weigh within one per cent. of perfect accuracy at any rate of supply up to its maximum capacity.

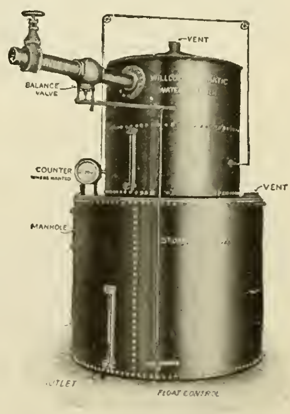
Styles and Capacities: The Willcox Water Weigher is built in several styles to suit various requirements: portable weigher for evaporative and condensing tests; and power plant sets for permanent installation. All capacities from one thousand pounds per hour up to half a million pounds.

Plans for Installation: Suggestions, sketches and plans for proposed installations are furnished free of charge by the Willcox Engineering Company. We have competent engineers and draftsmen for the purpose of assisting prospective customers in planning suitable arrangements to meet local conditions.

Savings Secured in Boiler Plants: By furnishing a simple, reliable, automatic self-recording device for continuously and accurately recording every pound of water pumped to the boilers, the Willcox Water Weigher offers a means of segregating boiler evaporation cost from engine and generator performance, thereby giving a sure means of determining from day to day whether or not a proper evaporation is being secured per pound of coal.

GENERAL DIMENSIONS—STYLE A BUILT OF BOILER PLATE

Size No.	Maximum rate of weighing, in lbs. of water per hour	Size Inlet, In.	Shell, Thickness	Approximate Ship'g Weight	Approximate Weight of water per unit charge
1	500,000	10	3/8	4000	5000
3	300,000	8	5/16	3000	3500
5	200,000	6	1/4	2100	2700
7	150,000	6	1/4	1850	2250
9	100,000	6	3/16	1500	1800
11	75,000	4	3/16	1200	....
12	62,500	4	3/16	1100	1180
STYLE B—INGOT IRON					
14	40,000	3	....	600	680
16	25,000	2½	....	400	420
18	15,000	2	....	275	200
20	10,000	2	....	175	120
22	5,000	1½	....	150	60



The Willcox Automatic Water Weigher with Storage Tank. Style A

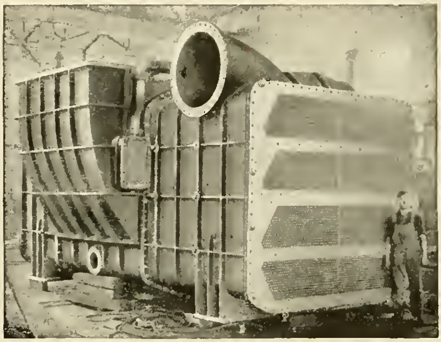
WHEELER CONDENSER AND ENGINEERING CO.

MAIN OFFICE AND WORKS: CARTERET, NEW JERSEY

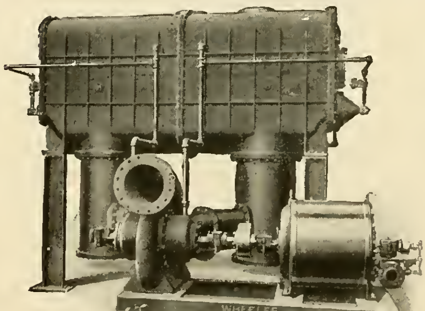
BRANCHES

New York, Boston, Philadelphia, Chicago, St. Louis, St. Paul, Cincinnati, Pittsburgh, Dallas, Cleveland, Denver, San Francisco, Salt Lake City, Los Angeles, Seattle, Portland, Tucson, Ariz., Charlotte, New Orleans, Atlanta, London, Yokohama, Trieste, Melbourne, Paris.

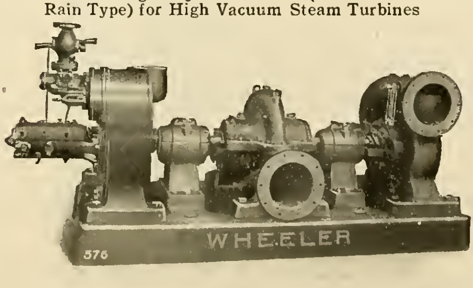
MANUFACTURERS OF COMPLETE CONDENSING EQUIPMENTS



Wheeler Dry Tube Surface Condenser



Wheeler Rectangular Jet Condenser (Counter-Current Rain Type) for High Vacuum Steam Turbines



Wheeler Combined Surface Condenser Auxiliaries Comprising Turbine Circulating Pump and Combined Condensate and Turbo Air Pump

HIGH VACUUM SURFACE CONDENSERS.

For turbines of any capacity, condensing equipments operating on wet or dry system, tube surface of condenser arranged to give best distribution of steam for high efficiency and designed on the dry tube principle to give maximum rate of heat transmission. Built as base condensers for vertical turbines, also for horizontal turbines with either rectangular or cylindrical shells.

HIGH VACUUM JET CONDENSERS.

For turbines of any size to maintain vacuum of 28 inches and up. Built on the countercurrent "rain type" principle to insure maximum temperature of discharge water, and therefore, minimum quantity of water, and minimum pumping cost.

WHEELER TURBO AIR PUMPS.

High Speed Rotary type for jet or surface condensers. Direct connected to turbine or motor. Will maintain 98-99% vacuum.

WHEELER-EDWARDS AIR PUMPS FOR AIR AND CONDENSATE.

Eliminate expense of independent air and hot well pumps. No suction or bucket valves.

WHEELER ROTATIVE DRY VACUUM PUMP.

Will maintain a vacuum within .5″ of barometer. For high vacuum jet condensers and large dry tube surface condensing equipments. Clearance effect reduced by rotative sniff valve.

CENTRIFUGAL PUMPS FOR ALL SERVICES.

Circulating, tail water and hot well pumps for condensing work. Pumps of all sizes driven by motor, steam turbine or engine for water works, irrigation, etc.

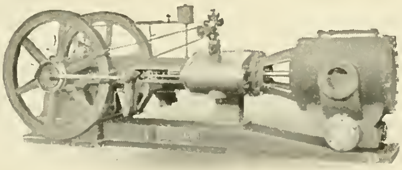
FORCED DRAFT STEEL TOWERS.

Recommended for efficient cooling of water where ground space is limited, and smallest size tower must be used.

NATURAL DRAFT WOODEN TOWERS.

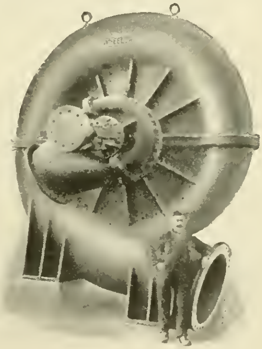
For manufacturing and industrial plants, also central stations where a supply of cooling water is not available. Operating costs consists of water pumping cost only. Designed for special low lift so as to reduce this cost to the minimum.

WHEELER CONDENSER AND ENGINEERING CO.

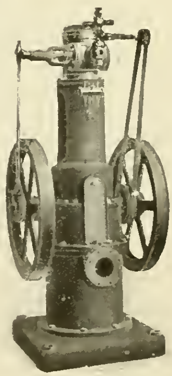


Wheeler Rotative Valve Reciprocating Dry Vacuum Pump

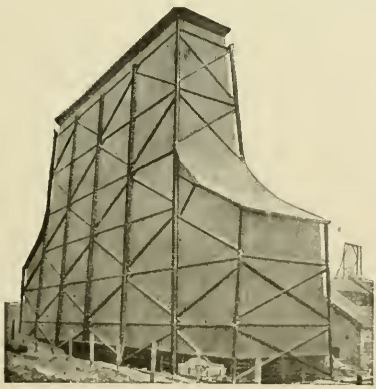
Wheeler Barometric Condenser



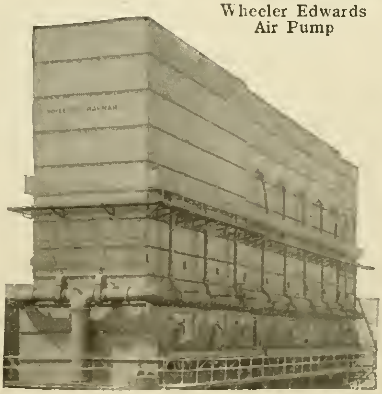
Wheeler Centrifugal Pump



Wheeler Edwards Air Pump



Wheeler-Balcke Natural Draft Wooden Cooling Tower



Wheeler-Barnard Forced Draft Cooling Tower

EDWIN BURHORN COMPANY

71 WALL STREET NEW YORK CITY

WATER COOLING TOWERS. RIVETED PIPE.
INTERNALLY FIRED BOILERS.

BURHORN AND ACME COOLING TOWERS

The tower illustrated herewith is of the open type, as the majority of plants are so designed that this type will show maximum efficiency. We are prepared, however, to furnish cooling towers of the closed type embodying all the economical characteristics of the open towers, but provided with stacks for natural draft or equipped with fans for forced draft.

VALUE OF COOLING TOWERS

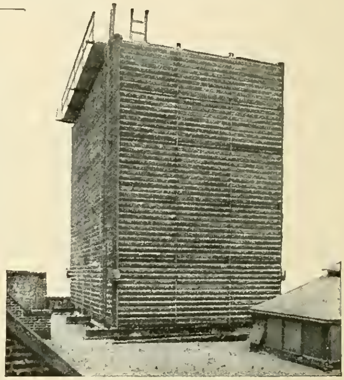
In any installation requiring water for cooling purposes a cooling tower is a valuable adjunct and a source of economy, unless there is available an abundant supply of cold, clean, pure water.

In many cases the use of water from the city supply would be perfectly satisfactory were it not for the excessive cost. By installing our cooling tower, however, only 2% to 5% of the water otherwise necessary will be required, and the cost of the supply is reduced proportionally.

CONSTRUCTION

Our towers are built of steel throughout and are practically indestructible. All parts are in plain sight and are readily accessible for inspection, cleaning, painting, etc.

Catalog on request.

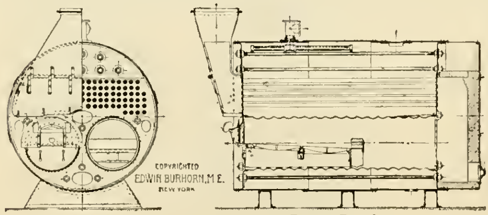

Water Cooling Tower

INTERNALLY FIRED BOILER

This type of boiler is compact, requires little head room as compared with other types of boiler, and recent tests have proved it as efficient and as suitable for high pressures as any type of water tube boiler. This type of boiler requires no brick setting, and has no water legs or other restricted place to become clogged with sediment. Every part of the interior is readily accessible and may be kept in a high state of efficiency.

Manufactured in seven standard sizes ranging from 75 to 300 h. p. Special sizes designed to meet special conditions.

Catalog on request.



End View **Cross Section**

INTERNALLY FIRED BOILER

DIMENSIONS OF STANDARD SIZES

Horse Power	Diameter	Length	Furnace	Number of Tubes	Diameter of Tubes	Length of Tubes	Combustion Chamber	Fire Brick Lining	Smoke Outlet Diam.	Steam Outlet	Safety Valve	Feed	Blow Off
75	78″	14′9″	36″	42	3½″	11′6″	24″	9″	20″	3″	2½	1¼	1½
100	84″	15′9″	38″	56	3½″	12′6″	24″	9″	23″	3½″	3	1¼	1½
125	90″	15′9″	45″	70	3½″	12′6″	24″	9″	26″	4″	3½	1½	2
150	96″	16′3″	50″	80	3½″	13′0″	24″	9″	28″	4½″	4	1½	2
200	114″	15′9″	2–38″	108	3½″	12′6″	24″	9″	33″	5″	4½	1½	2½
250	126″	15′9″	2–45″	137	3½″	12′6″	24″	9″	36″	6″	5	2	2½
300	138″	16′3″	2–50″	161	3½″	13′0″	24″	9″	40″	7′	5½	2	3

RIVETED STEEL PIPE

The most apparent advantages of Riveted Pipe over Cast Iron in large sizes are:

Uniformity in thickness and material.

Absence of Blow holes.

No shrinkage strains.

Decreased freight and haulage charges.

Cheapened erection and handling cost.

Less resistance to flow of contents.

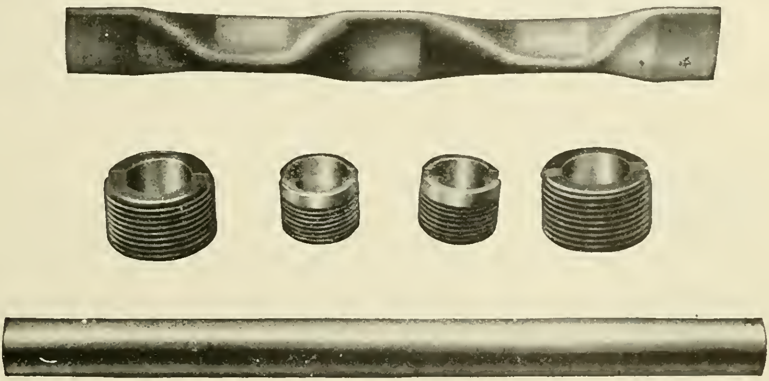
Safety from damage due to hidden defects.

Catalog on request.

BRIDGEPORT BRASS COMPANY

96 Crescent Avenue BRIDGEPORT, CONN.

MANUFACTURERS OF SEAMLESS DRAWN BRASS AND COPPER TUBING FOR ALL PURPOSES, ALSO CONDENSER TUBES—BRASS AND ADMIRALTY MIXTURE, TINNED AND PLAIN, ALSO FERRULES OF ALL KINDS. "BRIDGEPORT" SEAMLESS TUBING IS GUARANTEED TUBING OF THE HIGHEST QUALITY.



Our experience in manufacturing high grade Condenser Tubes enables us to meet the most exacting requirements. We have made a careful study of this particular class of work, and with this experience and the most approved methods at our command, *"Bridgeport" Condenser Tubes* represent quality of the highest standard.

Every tube is rigidly tested and inspected before shipment is made.

The severity of the requirements in modern power station service demands the highest grade of Condenser Tubes—*For Condenser Tubes of Quality specify* "Bridgeport."

Bronzes. In rod and sheet.

"Bridgeport," a special bronze. Great tensile strength and high elastic limit, for shafting, piston or plunger work. Also Manganese, Aluminum, Phosphor and Silicon Bronze.

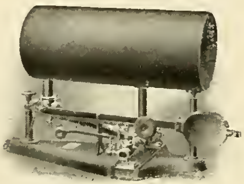
Special Shapes. Drawn or stamped from Brass, Copper, Bronze and German Silver. We make the article from the ingot to the finished product. Send sample or blueprint for estimate of price.

MOREHEAD MFG. CO.

DETROIT, MICH.

TILTING STEAM TRAPS, RETURN, NON-RETURN, VACUUM AND CONDENSER TYPES, FOR DRAINING HIGH OR LOW PRESSURE AND VACUUM HEATING SYSTEMS OF WATER OF CONDENSATION, and where desired, returning the condensation to the boiler as feed water. There is a Morehead Steam Trap to meet every condition arising in a steam or gas plant.

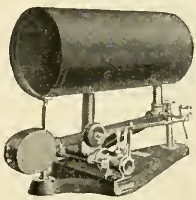
RETURN STEAM TRAP



Morehead Return Steam Trap

The Return Steam Trap removes water of condensation from heating, drying and cooking apparatus and returns the condensation direct to the boilers regardless of any difference in pressure on the apparatus drained and the boiler or whether the apparatus is located above or below the water line. It is admirably adapted for use as a lift pump and for feeding boilers from open or closed heaters. It handles perfectly, water at any temperature.

NON-RETURN TRAP



Morehead Non-Return Steam Trap

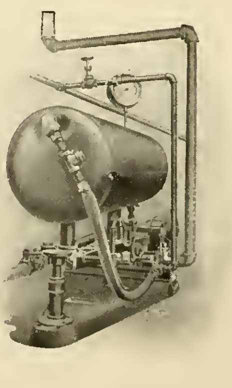
This type of Morehead Steam Trap is especially adapted to the removal of condensation from high or low pressure steam mains, dryers, heaters, etc., and delivering the water to an open tank, hot well or feed water heater. This trap has a removable seat and disc in the valve. It discharges from low point, insuring an effective *water seal* at all times. It is guaranteed for 200 lbs. working pressure.

VACUUM TRAP

The Vacuum Trap removes automatically all condensation from exhaust lines and oil separators operating under a vacuum without breaking or impairing that vacuum. It delivers the water of condensation to any desired point above or below the location of the trap and is guaranteed not to affect the vacuum in in any way.

CONDENSER TRAP

The Condenser Trap is a combination of the features of a Morehead Automatic Return Trap and the Jet or Spray Condenser. It is especially adapted to service on exhaust steam and reduced pressure heating, cooking and drying apparatus. The *positive vacuum* formed in the tank of the trap removes rapidly all condensation in the system, accelerates the travel of the steam and reduces the back pressure on the engine.



Morehead Condenser Trap

This is a cut of an actual installation. The check valves and gage shown in cut are only furnished as extras.

MOREHEAD TILTING NON-RETURN STEAM TRAPS
Sizes and Capacities

No.	Inlet Inches	Outlet Inches	Capacity in Water Discharged per Hour	Drainage Capacity in 1 inch Pipe Lineal	Capacity Square Feet Direct Radiation	Capacity Lineal Feet Hot Blast Heater	Weight
21	1	1	200 gal.	12000 ft.	3000	1300	100
22	$1\frac{1}{4}$	$1\frac{1}{4}$	400 "	25000 "	5200	2400	175
23	$1\frac{1}{2}$	$1\frac{1}{2}$	600 "	40000 "	12000	5200	250
24	2	2	720 "	60000 "	21000	9000	275
25	$2\frac{1}{2}$	$2\frac{1}{2}$	900 "	90000 "	33000	16000	350
26	3	3	1300 "	140000 "	50000	25000	450

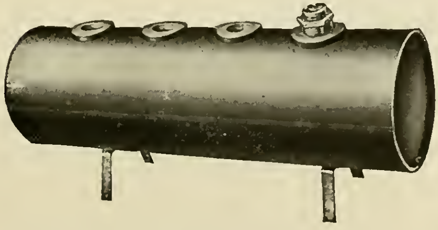
MOREHEAD TILTING RETURN, VACUUM AND CONDENSER STEAM TRAPS
Sizes and Capacities

No.	Size of Drum	Size of Inlet and Outlet Connections Inches	Size of Steam Pipe Connections Inches	Capacity of Water in Lbs. per Hour	Drainage Capacity in feet of 1 inch Pipe Lineal	Capacity Square Feet Direct Radiation	Capacity Lineal Feet Hot Blast Heater	Weight
1	10 x 24	1	1	1050	5000	2300	1000	100
2	12 x 30	$1\frac{1}{4}$	1	1850	9000	4000	1800	175
3	14 x 36	$1\frac{1}{2}$	$1\frac{1}{4}$	4000	20000	9000	4000	250
4	16 x 40	2	$1\frac{1}{4}$	6000	35000	16000	7000	275
5	18 x 42	$2\frac{1}{2}$	2	11000	50000	25000	12000	350
6	18 x 42	3	2	15000	75000	40000	18000	400

The above capacities are figured on a basis of 50 pounds pressure to the square inch. The above drainage capacity in inch pipe is based on ordinary radiating conditions. For lumber kilns, greenhouses and moist goods, divide by two. For laundries, brick dryers and wet goods, divide by three. For fan stacks and blowers, divide by five.

NOTE—3 feet of 1 inch pipe equals one square foot of surface. 2.3 feet of $1\frac{1}{4}$ inch pipe equals one square foot of surface. 2 feet of $1\frac{1}{2}$ inch pipe equals one square foot of surface. 1.61 feet of two inch pipe equals one square foot of surface.

MOREHEAD RECEIVERS



No.	Length Inches	Height Inches	Diameter Inches
1	30	16	10
2	40	20	12

No. 1 Receiver has capacity for Traps Nos. 1 and 2. No. 2 Receiver has capacity for Traps Nos. 3, 4, 5 and 6.

We will be glad to advise regarding the installation of traps to meet the conditions of your steam system.

PENBERTHY INJECTOR CO.

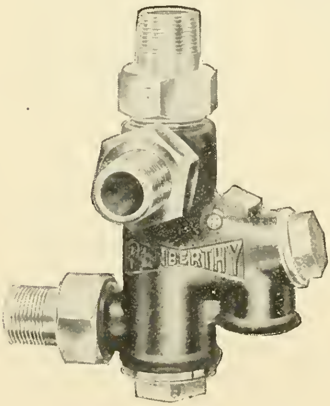
DETROIT, MICH.

New York City; Windsor, Can.; London, Eng.; Hanover, Germany and Paris, France

MANUFACTURERS OF INJECTORS, EJECTORS, STEAM SPECIALTIES AND LUBRICATING DEVICES.

TRADE PENBERTHY MARK.

AUTOMATIC INJECTORS



All our claims for the "Penberthy" Injector are based on actual tests, as we have set for this machine a very high standard, which for years has been steadily advanced, and the "Penberthy" to-day is better than ever before. Every "Penberthy" Injector is carefully tested before leaving the factory, and no machine is allowed to go out that will not work on the following points, while nearly all of them will do much better:

Start Low, 20 to 22 lbs. steam on 3-foot lift.
Work High, 165 to 170 lbs. steam on 3-foot lift.
Lift Water, 20 to 24 feet on 60 to 80 lbs. steam.
Handles Hot Water,
125° to 130° at 60 to 80 lbs. steam.
115° to 120° at 100 lbs. steam.
95° to 104° at 125 lbs. steam.

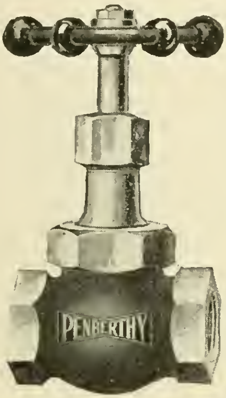
Automatic Qualities.—The Penberthy is a perfect restarting automatic machine. By this we mean, when the Injector is working and forcing water to the boiler, if the current of water be suddenly broken by any cause, such as a sudden jar or jolt, as in the case of a traction engine or road roller or in the case of a marine boiler, by the rolling of the vessel throwing the sea-cock out of the water for a moment, the Injector will pick up the water and again establish the current to the boiler automatically, without the manipulation of a single valve or the least attention from an attendant.

"XL-96" IMPROVED EJECTOR

The *lifting* and *elevating* power is so combined in the XL-96 ejector as to make it unquestionably the best device of its kind. All other ejectors which will lift 20 feet will elevate but 20 to 25 feet additional, and this only on very limited steam pressures, and it is therefore necessary to locate other ejectors to within a few inches of the surface of water and operate with excessive steam pressure if it is desired to transfer water any great distance vertically. The XL-96 ejector lifts 22 to 25 feet. Elevates 25 to 100 ft. 30 to 100 lbs. pres. *Write for further information.*

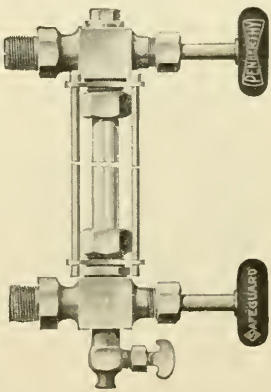
PENBERTHY INJECTOR CO.

REGRINDING GLOBE VALVES



The ever increasing demand to-day by Power Plant owners and steam users in general is for valves that will give absolutely reliable service and dependability under high pressures and severe conditions, and that are free from unnecessary renewal of discs and repair parts. To meet this demand the Penberthy Regrinding Valve has been designed. It is the result of many years practical experience in the manufacture of high grade brass goods, and embodies the best mechanical ideas ever employed in mechanical construction. It is the heaviest regrinding valve manufactured, and the distribution of metal is such that parts subjected to the greatest strain and wear have proportionately heavier walls. For the present we illustrate only the medium pattern type, which we guarantee to stand a constant working pressure of 200 pounds.

SAFEGUARD WATER GAGE

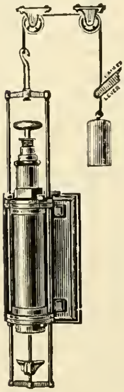


The Penberthy Safeguard Automatic Water Gage is tested to 300 pounds and given a thorough examination before being sent out from the factory. *Constructed* simple and strong, there are no springs or levers to get out of adjustment, no unnecessary parts or complications. Operates on any pressure. *Self-Cleaning* by the action of the blow-off vibrating the balls. The cleaning stem in lower shank goes all the way through into the boiler, absolutely preventing opening from ever being closed by scale, etc. All dirt, deposit and sediment is forced out through pet-cock each time glass is blown. *Balls cannot seat unless the glass is broken* because the upper ball seat is designed to leak. This leak can never be stopped accidentally, as the ball seat is square in the $\frac{3}{8}''$ and $\frac{1}{2}''$ sizes and hexagonal shaped in the $\frac{3}{4}''$ size, allowing passages which, because of their shape and size, can never become clogged. This leak, also, is positively necessary to insure perfect operation of an automatic gage. It is the only mechanical means of preventing a false water level from being shown, and any automatic gage not so constructed is, for that reason, unsafe. The Penberthy dripless pet-cock, with which all Safeguard Gages are equipped, is slow-opening and closing, thus allowing the blowing off of the gage to be done gradually, which prevents the balls from seating as they might do in shutting off the quick-opening and closing pet-cock, with which all other automatic gages are equipped. *Write for further information.*

JULIAN D'ESTE COMPANY

24 CANAL ST., BOSTON, MASS.

BRASS FOUNDERS, FINISHERS AND MACHINISTS, SOLE MANUFACTURERS OF CURTIS ENGINEERING SPECIALTIES, INCLUDING DAMPER REGULATORS, IMPROVED PRESSURE REGULATORS, IMPROVED PUMP REGULATORS, WATER PRESSURE REGULATORS, EXPANSION TRAP, RETURN STEAM TRAP, BALANCED STEAM TRAP, RELIEF VALVE FOR STEAM AND WATER, STEAM SEPARATOR, TEMPERATURE REGULATOR, PUMP GOVERNOR AND PUMP, BLOWER VALVE, CELLAR DRAINER, U. S. BALL COCK, ETC.


Damper Regulator

THE CURTIS IMPROVED (PATENT) DAMPER REGULATORS

The plunger is operated by steam direct from the boiler, and the whole pressure in the boiler is therefore available to operate the damper if needed. In practice, only enough pressure is used to lift the weight, usually not more than ten pounds to the square inch on the plunger.

The motion of the damper will begin to change from one direction to the other on a variation of steam pressure of one half of a pound either way from the point at which it is set to operate.

We guarantee a saving of ten per cent of the fuel over the best hand regulation or the old style (diaphragm and lever regulator), and it often reaches fifteen per cent.

They are sent on thirty days' approval and will pay their cost by the saving of fuel in one year. *Three Standard Sizes.*

IMPROVED STEAM PRESSURE REGULATORS

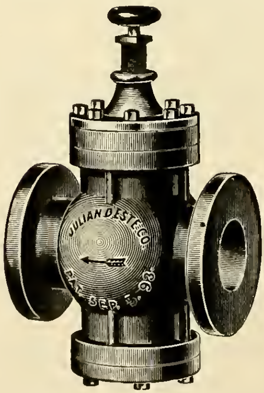
This regulator is made entirely of metal, occupies the same space as a globe valve for the same size pipe, and is very simple and sensitive.

By its use steam may be maintained at high pressure in boilers, and yet be reduced for heating to two or three pounds.

In the best engineering practice the exhaust steam of the engine and elevator is turned into the heating system of a building, and the Regulator automatically supplies just the amount lacking to maintain constant pressure in the pipes and radiators.

Standard sizes for 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, 7, 8, 10, 12, 14, and 16 inch pipe.

A lockup top furnished at small additional cost.

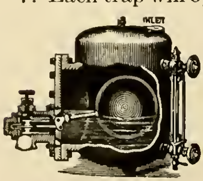


Steam Pressure Regulator

THE CURTIS BALANCED STEAM TRAP

Some Points of Superiority

1. A perfectly balanced valve.
2. An absolutely frictionless valve.
3. The valve can be removed without breaking a joint, starting a gasket, or taking out a bolt.
4. The valve being frictionless and balanced, the whole power of the float is available for opening and closing the valve.
5. The copper float is perfectly spherical, hard, as hermetically sealed as a glass globe, is of uniform thickness and warranted strong and tight at 250 lbs. pressure.
6. It has a pass-by valve to insure constant operation.
7. Each trap will operate perfectly on pressures varying from one to 250 pounds.



Balanced Steam Trap

PRICE LIST

Size and Condensing Capacity in Feet of One-Inch Pipe

No. 000,	$15.00	for	1,000 feet	½	in. inlet and outlet
No. 00,	20.00	for	2,000 feet	½	in. inlet and outlet
No. 0,	25.00	for	3,000 feet	½	in. inlet and outlet
No. 1,	30.00	for	5,000 feet	¾	in. inlet and outlet
No. 2,	40.00	for	8,000 feet	1	in. inlet and outlet
No. 2½,	55.00	for	15,000 feet	1¼	in. inlet and outlet
No. 3,	75.00	for	30,000 feet	1½	in. inlet and outlet
No. 4,	100.00	for	40,000 feet	2	in. inlet and outlet
No. 5,	125.00	for	60,000 feet	3	in. inlet and outlet

McNAB & HARLIN MFG. CO.

55 John Street, NEW YORK CITY

BRASS AND IRON GOODS: FITTINGS, VALVES, COCKS, PIPE, ETC., FOR STEAM, WATER AND GAS

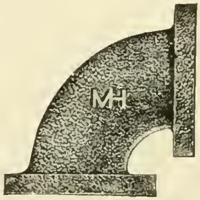
CAST IRON FITTINGS—SCREWED

"MH" Fittings are made of the best quality grey iron and threaded to Briggs Standard Gauge. We have a complete line of patterns for all styles, in both Standard and Extra Heavy.

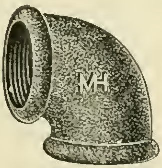
In addition to our full line of steam fittings, we have a complete line of patterns for Drainage Fittings, and Long Turn Fittings particularly adapted to Sprinkler Work.

CAST IRON FITTINGS—FLANGED

We carry a very large and complete stock of both Standard and High-Pressure Flanged Fittings, in all styles and sizes, and are in a position to furnish these goods, which are designed for high grade power plant installation, on very short notice.



BRASS FITTINGS

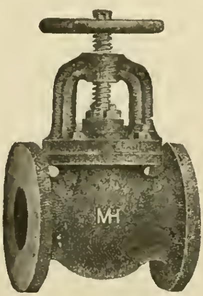


"MH" Brass Fittings are made from a standard composition best suited for this class of work. Having a complete line of patterns for both Flanged and Screwed, we are in a position to furnish these Fittings from the Malleable and the Cast Iron patterns very promptly.

STEAM METAL VALVES

Our line of patterns for Steam Metal Valves in the different styles, viz.: Globe, Angle, Cross, Gate and Check, is very complete, and we are in a position to furnish these goods to stand all requirements, from the ordinary pressures to the extreme high pressures, which we find are being used more extensively every day. We have just added to the extensive line of "MH" goods, a complete set of patterns for "MH" Regrinding Valves. These Valves are made of the best quality steam metal and are equal to any Regrinding Valve on the market.

IRON BODY VALVES



We manufacture a complete line of "MH" Iron Body Valves, in Globe, Angle, Cross, Gate and Check, both Flanged and Screwed, Inside Screw and O. S. & Y. In keeping with our line of Brass Valves, we have a full set of patterns for these goods, both Standard and Extra Heavy, and recommend them to give perfect satisfaction, as the materials entering into their manufacture are of a high grade, and the workmanship first class.

We are devoting special attention to Power Plant Installation, and solicit your inquiries for the material required in this line of work.

For a complete description and dimensions of the full line of "MH" goods, we refer you to our illustrated catalog, which can be obtained on application.

CRANE CO.

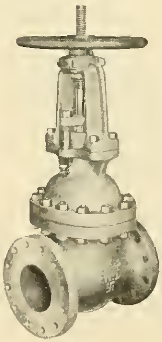
836 So. Michigan Ave., CHICAGO, ILL.

Cable address, Cranecoy, Chicago. Branches in Forty-four Cities.

CAST STEEL VALVES AND FITTINGS; CRANETILT STEAM TRAPS; VALVES, COCKS AND FITTINGS IN BRASS, MALLEABLE IRON AND CAST IRON; STEAM SPECIALTIES; COMPLETE PIPING EQUIPMENT; PIPE BENDS; PIPE FITTERS' TOOLS; ENGINEERS' SUPPLIES, ETC.

CRANE CAST STEEL VALVES AND FITTINGS

We have been manufacturing for some time a line of steel fittings to meet a steadily growing demand for a superior grade of goods, especially adapted for High Pressure, Saturated and Superheated Steam Lines and Extreme Hydraulic Service. These are suitable for steam working pressures up to 350 pounds, and for superheat up to a total temperature of 800 degrees.

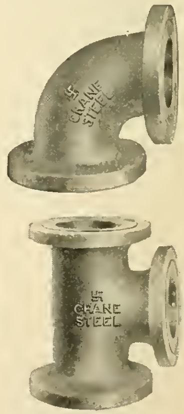


No. 7A

Cast steel body, bonnet, yoke and disc (sizes above 2 inch, disc nickel faced; 2 inch and smaller, solid nickel disc) nickel seats and rolled Monel Metal Stem.

Nos. 21A, 23A and B, 27A, 29A and B

Cast steel body, yoke and swivel disc (sizes above $3\frac{1}{2}$ inch, disc nickel faced; $3\frac{1}{2}$ inch and smaller, solid nickel disc) nickel seats and rolled Monel Metal or steel stems.



No. 101D and No. 105D

Extra Heavy Cast Steel Flanged Fittings,

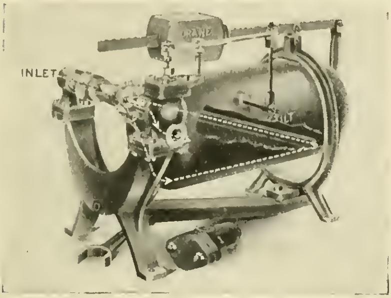
We carry the following steel goods in stock:

No. 7A Straight-Way Valves Outside screw and yoke, nickel seats, rolled Monel Metal stem.	12 inch and smaller
No. 9A Straight-Way Valves Outside screw and yoke, nickel seats, rolled Monel Metal stem.	14 inch and smaller
No. 21A Globe Valves Outside screw and yoke, nickel seats, rolled Monel Metal stem.	6 inch and smaller
No. 23A and B Angle Valves Outside screw and yoke, nickel seats, rolled Monel Metal, or cold rolled steel stems.	6 inch and smaller
No. 101D Steel Flanged Elbows Straight sizes.	12 inch and smaller
No. 105D Steel Flanged Tees Straight sizes.	12 inch and smaller
Screwed Elbows Straight sizes.	4 inch and smaller
Screwed Tees Straight sizes.	4 inch and smaller

Further particulars will be found in our Special Steel Catalogue No. 70, October 1910.

CRANE CO.

CRANETILT STEAM TRAPS

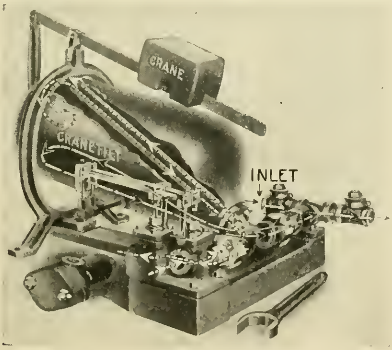


NON-RETURN PATTERN

The receiving or tilting tank is made of malleable iron, cast in one piece of uniform thickness. They are tested to 800 pounds hydraulic pressure per square inch and are fully capable of withstanding the severe strains to which Tilting Traps are subjected.

All operating parts are on the outside and the Discharge Valves are of special design, having exceptionally large openings. The brass working parts are made of "Crane Hard Metal" which has wearing qualities almost equal to steel and successfully resists the cutting effects of steam and water.

		Pipe Connections	Capacities per Hour Based on Ordinary Condensing Conditions		Dimensions	
Size of Trap Number	List Price including Sediment Trap, but no Check Valves or Fittings	Size of Inlet and Outlet Inches	Lineal Feet of 1 Inch Pipe Trap will Drain with 50 lbs. Pressure at the Trap	Pounds of Water Discharged with 50 lbs. pressure at the Trap	Over All Inches	Extreme Height Inches
30	$25.00	¼	6,000	1,200	19½x12	19¾
32	45.00	½	15,000	3,000	24½x14⅝	24½
33	55.00	¾	30,000	6,000	28 x18¼	28
34	85.00	1	50,000	10,000	32½x20½	31
35	115.00	1¼	75,000	15,000	36 x23	33
36	150.00	1½	100,000	20,000	42 x25½	36
37	200.00	2	150,000	30,000	47½x29⅛	41
38	300.00	2½	200,000	40,000	54 x33⅛	50
39	425.00	3	250,000	50,000	61 x37¾	56



DIRECT RETURN PATTERN

This pattern will automatically return all condensations, at any pressure or temperature, directly back into the boiler. Direct Return Traps require live steam from the boiler for their operation, which is automatically controlled through the steam port of the Duplex Valve. Cranetilt Steam Traps will handle condensation from all sources, under any condition of service, and under any pressure up to 250 pounds. They also have a maximum discharging capacity. Each trap is given a thorough steam test and guaranteed in perfect working order before shipment.

		Pipe Connections		Capacities per Hour Based on Ordinary Condensing Conditions		Dimensions	
Size of Trap Number	List Price including Sediment Trap, Two Swing Check Valves, Tee and Nipples	Size of Water Inlet and Discharge Inches	Size of Steam and Vent Valve Inches	Lineal Ft. of 1 Inch Pipe Trap will Drain	Pounds of Water Trap will Discharge into Boiler	Over All Inches	Extreme Height Inches
90	$60.00	½	½	4,000	800	25 x15¾	27
91	75.00	¾	¾	7,500	1,500	28¼x19⅛	31
92	100.00	1	1	12,500	2,500	33 x21¾	36
93	150.00	1¼	1¼	18,000	3,600	37½x24½	38
94	200.00	1½	1½	25,000	5 000	42½x27	42
95	300.00	2	2	39,000	7,800	51½x30¼	50
96	400.00	2½	2½	57,500	11,500	60 x34½	55
97	550.00	3	3	77,500	15,500	68 x38¾	65
98	750.00	4	3	140,000	28,000	76 x44¾	70

(See also following pages)

(Continued from preceding pages)

CRANE CO.

CHICAGO, ILL.

SUMMARY OF CRANE PRODUCTS

We give on this and the succeeding page a description of our line. We carry in stock at our branch houses a large supply of the goods listed below and are prepared to furnish SPECIAL VALVES, FITTINGS, etc., to meet specific requirements or conditions, without delay.

The term STANDARD is applied to those goods intended for working steam pressures not exceeding 125 pounds. The LOW PRESSURE FITTINGS, etc., may be used for STEAM WORKING PRESSURES up to 25 pounds, while the MEDIUM GOODS are intended for 175 to 225 pounds. The EXTRA HEAVY are designed for STEAM WORKING PRESSURES up to 250 pounds.

The proportionate WATER WORKING PRESSURES may be taken as follows: LOW PRESSURE, STANDARD and MEDIUM, 40 per cent greater than the steam pressure on sizes 12 inch and smaller; sizes 14 inch and larger, 20 per cent greater.

STANDARD GOODS

We manufacture brass GLOBE, ANGLE and CROSS VALVES, screwed, in sizes from 1/8 to 4 inches; and the flanged pattern from 3/4 to 4 inches. The brass CHECK VALVES are made in many patterns, the sizes of which run from 1/8 to 3 inches. The brass line also includes: HOSE, GARDEN HOSE, COKE OVEN, NEEDLE POINT, STRAIGHT-WAY and HOSE GATE. Our lines of RADIATOR VALVES and FITTINGS, BRASS, STEAM and GAS COCKS are complete. The CAST IRON FITTINGS include COCKS of various patterns; GLOBE, ANGLE and CROSS VALVES with yoke as well as the regular patterns; the sizes of the latter ranging from 1/2 to 3 inches. We handle BRASS and CAST IRON PIPE FITTINGS in both the screwed and flanged patterns as well as MALLEABLE PIPE FITTINGS screwed. With the STANDARD GOODS are also included IRON STRAIGHT-WAY VALVES, EXPANSION JOINTS with iron body and brass sleeve, RAILING FITTINGS, DRAINAGE FITTINGS, STEAM FITTERS' and ENGINEERS' TOOLS, PIPE BENDS, and PIPE SUPPORTS, BRACKETS, etc.

LOW PRESSURE GOODS

The ALPHA STRAIGHT-WAY WEDGE GATE VALVES have been designed for use in connection with hot water and low pressure steam heating systems and plumbing, and are made in sizes ranging from 1/2 to 2 inches. The regular low pressure STRAIGHT-WAY or WEDGE GATE VALVES are made in several patterns and in sizes up to 72 inches. The low pressure PIPE FITTINGS are of the flanged pattern and include ELBOWS, 45 degree ELBOWS, TEES, REDUCING TEES, CROSSES, REDUCING CROSSES, LONG RADIUS ELBOWS, SQUARE and ROUND BASE ELBOWS and TAPER REDUCERS.

MEDIUM PRESSURE GOODS

This line includes the CRANE NAVY GLOBE, ANGLE, CROSS and CHECK VALVES made of CRANE SPECIAL BRASS; the screwed pattern being made in sizes ranging from 1/4 to 4 inches and the flanged pattern from 3/4 to 4 inches. The brass STRAIGHT-WAY or WEDGE GATE VALVES come with non-rising stems, either screwed or flanged, while the rising stem pattern has a yoke and is screwed. We also make in the medium class, GLOBE, ANGLE and CROSS VALVES with FERROSTEEL body, flanged in sizes ranging from 2 to 12 inches; the STRAIGHT-WAY or WEDGE GATE FERROSTEEL VALVES are made in sizes up to 24 inches.

CRANE CO.

EXTRA HEAVY GOODS

Under this heading will be found FERROSTEEL STRAIGHT-WAY VALVES in ten patterns, including the ELECTRICALLY and CYLINDER OPERATED DESIGN; the sizes run up to 24 inches and larger. The FERROSTEEL GLOBE, ANGLE and CROSS VALVES are made with yoke, have hard metal seats and are flanged; the sizes range from 2 to 15 inches. The EXTRA HEAVY VALVE line also include SWING CHECK VALVES, flanged sizes from 2 to 15 inches; GLOBE and ANGLE THROTTLE VALVES, flanged, in sizes from 3 to 8 inches; AUTOMATIC STOP-CHECK VALVES in GLOBE and ANGLE PATTERN, flanged, sizes 2 to 15 inches; EMERGENCY STOP VALVES in sizes from 4 to 16 inches; EXPANSION JOINTS—iron body and brass sleeve, in sizes 2 to 18 inches—these are also made with special traverse and extra long traverse; BALANCED EXPANSION JOINTS; SWIVEL EXPANSION JOINTS; GLOBE, ANGLE, CROSS and CHECK VALVES; REGRINDING SWING CHECK VALVES; HORIZONTAL CHECK VALVES; UNIONS, ROUGH BRASS FITTINGS, MALLEABLE IRON FITTINGS, CAST IRON FLANGED FITTINGS, GASKETS, FLANGED PIPE JOINTS.

HYDRAULIC GOODS

All of these articles have been designed for water working pressures up to from 800 to 1200 pounds. The line includes STRAIGHT-WAY VALVES outside screw and yoke with or without by-pass in sizes from 1½ to 12 inches; SWING CHECK VALVES in sizes from 2½ to 12 inches; GLOBE, ANGLE and CHECK VALVES, MALLEABLE IRON FITTINGS, BRASS UNIONS, FERROSTEEL FLANGED FITTINGS and COMPANION FLANGES for pressures up to 2500 pounds; CAST STEEL HYDRAULIC VALVES, FITTINGS and FLANGES for pressures up to 3000 pounds.

PIPE

We can supply promptly SEAMLESS DRAWN BRASS and COPPER TUBING in iron pipe sizes, STANDARD WEIGHT SPIRAL RIVETED PRESSURE PIPE, STRAIGHT SEAM STEEL RIVETED PIPE, and WROUGHT PIPE—either black or galvanized.

SPECIALTIES AND TRIMMINGS

These are AUTOMATIC EXHAUST RELIEF VALVES, AUTOMATIC STOP CHECK VALVES, CHICAGO and NAVY UNIONS, BOILER FITTINGS, CRANE CEMENT for making tight pipe joints, STEAM WHISTLES, WATER GAUGES, OIL and GREASE CUPS, LUBRICATORS, COCKS, PRESSURE and VACUUM GAUGES, FUSIBLE PLUGS, BACK PRESSURE VALVES, LEVER SAFETY VALVES, POP SAFETY VALVES, BLOW-OFF VALVES, BLOW-OFF CROSSES, PRESSURE REGULATORS, FLOAT VALVES, EXHAUST PIPE HEADS, INJECTORS, AUTOMATIC DUPLEX FEED PUMPS and RECEIVERS, PUMPS, FLEXIBLE JOINTS, KLINGERIT PACKING, E. C. & B. PIPE MACHINES, STEAM and OIL SEPARATORS, CRANE VACUUM OIL SEPARATORS, MACHINE BOLTS.

POCKET CATALOGUE

We have just issued a new edition which will be found very complete and useful. It is designated as No. 40 and dated May 1913.

NATIONAL TUBE COMPANY

General Sales Offices, FRICK BLDG., PITTSBURGH, PA.

DISTRICT SALES OFFICES—Atlanta, Boston, Chicago, Denver, Kansas City, New Orleans, New York, Philadelphia, Pittsburgh, St. Louis, St. Paul, Salt Lake City.
PACIFIC COAST REPRESENTATIVES—U. S. Steel Products Co., San Francisco, Portland, Seattle, Los Angeles
EXPORT REPRESENTATIVES—U. S. Steel Products Co., New York City.

ONLY FULL STANDARD WEIGHT PIPE MADE IN THE FUTURE

Beginning January 1, 1913, the National Tube Company will manufacture only Full Standard Weight Pipe.

In the past, the diversified purposes for which pipe was used led to a number of so-called "Merchant" grades, varying to some extent from standard pipe. This change from standard weight was warranted for certain purposes, but the necessity for various stocks on the part of dealers produced uncertainty in the mind of the consumer as to the weight of pipe received, and from time to time substitutions were made.

The result of substituting a light weight pipe where standard weight should have been used frequently involved both trouble and misunderstanding, whereas full weight pipe, if there were no other, could be used just as well for all purposes where "Merchant" weight had been used.

To the ultimate consumer and user, who is not always equipped to weigh and inspect every length of pipe the advantages of a single HIGH standard are obvious.

MARKING

Name Rolled in Raised Letters on National Tube Co. Pipe

To readily identify "NATIONAL" material, and as protection to manufacturer and consumer alike, the practice of National Tube Company is to roll in raised letters of good size on each few feet of every length of welded pipe the name "NATIONAL" (except on the smaller butt-weld sizes, on which this is not mechanically feasible).

In addition, all sizes of "NATIONAL" welded pipe below four or five inches are subjected to a roll-knobbling process known as "Spellerizing" to lessen the tendency to corrosion, especially in the form of pitting. This "Spellerizing" process to which National Tube Company has exclusive rights, is peculiar to "NATIONAL" pipe.

To Summarize:

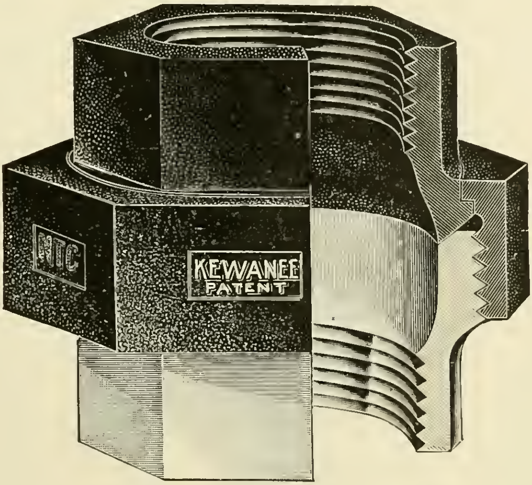
(*a*) The heavier pipe is stronger at the weld, more easily threaded, and the extra thickness adds just that much to the durability. (*b*) When specifications call for "NATIONAL" pipe it is not necessary to say "full standard weight," "Spellerized," nor any other qualifying phrase. The term "NATIONAL" pipe involves all of these.

Write today for a copy of "Modern Welded Pipe"—the book that tells about "NATIONAL" Pipe.

NATIONAL TUBE COMPANY

"KEWANEE" UNIONS

"Kewanee" Combination Brass and Iron Ground Ball Joint.



Octagon Pattern, Fig. H-300

"The Union with no Inserted Parts"

Five "Kewanee" Advantages

(a) Brass to iron thread connection--No corrosion.
(b) Brass to iron ball joint seat—No Gasket.
(c) 125 pounds compressed air test under water—No defective fittings.
(d) Solid, three piece construction—No inserted parts.
(e) Easily disconnected—No force required.

These advantages are common to each type and pattern of "Kewanee" Unions and "Kewanee" Specialties.

"*The Whole Kewanee Family,*" an illustrated book of 48 pages, contains valuable information to users of unions and other fittings. Ask for a copy—its free! A post-card will bring it to you.

Size.................inches	1/8	1/4	3/8	1/2	3/4	1	1 1/4
Black..................each	.18	.19	.22	.27	.40	.48	.66
Galvanized............. "	.22	.23	.26	.34	.49	.60	.82
Size.................inche	1 1/2	2	2 1/2	3	3 1/2	4	....
Black..................each	.80	1.14	2.10	2.65	4.30	5.50	....
Galvanized............. "	1.10	1.40	2.75	3.50	6.30	7.50	....

JEFFERSON UNION COMPANY

LEXINGTON, MASS.

UNIONS AND FLANGES FOR OIL, STEAM, WATER AND GAS UNDER ALL PRESSURES. Malleable iron only is used for standard goods and brass tubing for rings for seats.

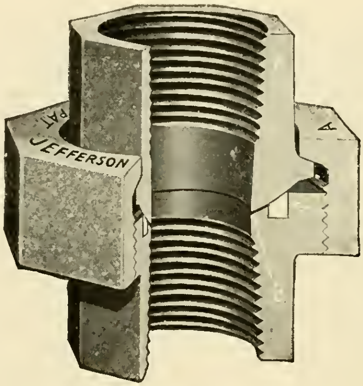


Fig. A 4
JEFFERSON UNION
All Female

Jefferson Unions are made with spherical brass to iron seats ground to a perfect fit. The ring R is of wrought metal, cut from seamless brass tubing, avoiding blowholes common in cast brass. There are special advantages in the use of the brass ring in just the manner shown and the wall B is patented owing to these advantages, which include protecting the brass from injury no matter how far the pipe is screwed in. No gasket is used and there is plenty of play for the part F which swivels in the nut.

The following illustrations show a few of the many styles in which these unions are made including Male and Female, All Male, 90° and 45° Elbows, Tees, and Reducing.

The Swing Union (Fig. A17) may be used for any angle.

The Three Part Flange (Fig. A29) for use where pressures do not exceed 200 pounds is very economical. In applying, the ends are screwed onto the two pieces of pipe. Then the loose collar is swiveled around and the bolt holes in the flanges brought into position for screwing down the nuts without a moment's delay. Owing to the ball joint, the Jefferson Flange Union will make up as tight when the pipes are slightly out of line as when they are in line.

The Two Part Flange (Fig. A30) is made in two weights, the Style D for pressures to 500 lbs., and the Style E, extra heavy, for pressures to 1000 lbs.

All Jefferson Unions are made with Brigg's Standard Taper Pipe Threads.

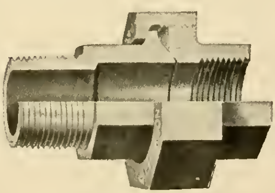


Fig. A 5
MALE AND FEMALE

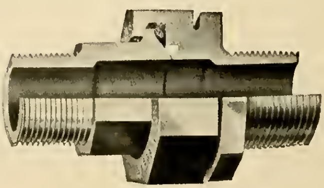


Fig. A 7
ALL MALE

JEFFERSON UNION COMPANY

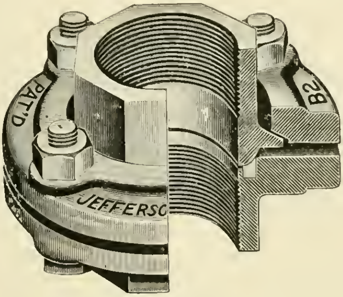


Fig. A 29
JEFFERSON FLANGE UNION
Three Part

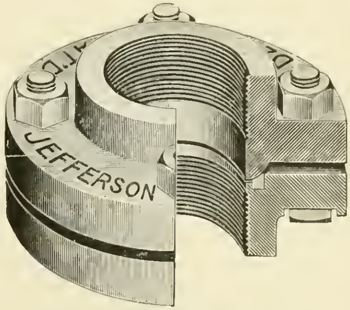


Fig. A 30
JEFFERSON FLANGE UNION
Two Part

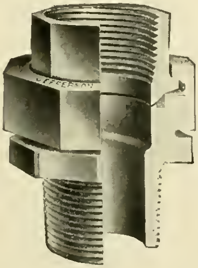


Fig. A 6
MALE AND FEMALE

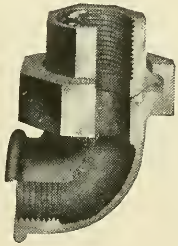


Fig. A 9
90° UNION ELBOW
All Female

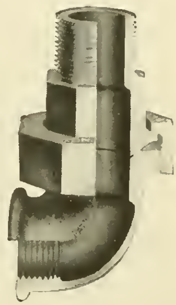


Fig. A 10
90° UNION ELBOW
Male and Female

Fig. A 12
45° UNION ELBOW
Male and Female

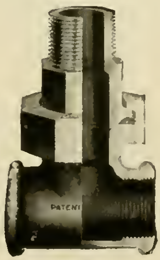


Fig. A 16
TEE-UNION ON OUTLET
Male and Female

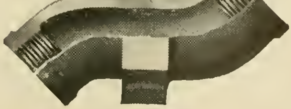


Fig. A 17
SWING UNION

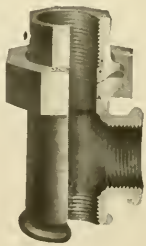
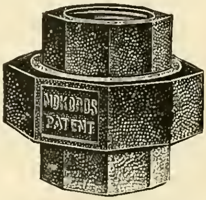


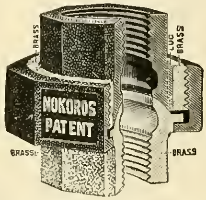
Fig. A 13
TEE-UNION ON RUN
All Female

ILLINOIS MALLEABLE IRON CO.

1801-25 DIVERSEY PARKWAY, CHICAGO, ILL.

THE NOKOROS PATENT UNION

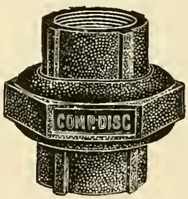


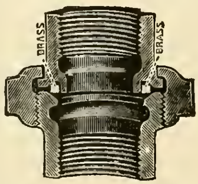


The only Union made absolutely NON-CORROSIVE at all contact points.
Non-corrosive Brass to Iron thread connection.
Non-corrosive Brass to Iron seat between ring and tail-piece.
Octagon shape, a monkey wrench will turn.

Size, inches	¼	⅜	½	¾	1	1¼	1½	2	2½	3
Plain, each	.19	.22	.27	.40	.48	.66	.80	1.14	2.10	2.65
Galvanized, each	.23	.26	34	.49	.60	.82	1.10	1.40	2.75	3.50

THE COMPRESSION DISC PATENT UNION

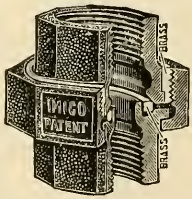


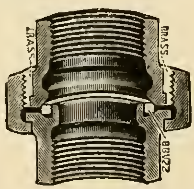


Heavy Pattern Air Furnace Malleable Iron with Brass Valve Seated Disc. The face of each threaded section is beveled to receive a brass disc, and the connecting up of the union COMPRESSES the brass DISC against the recesses, making a permanent steam metal seat.

Size, inches	¼	⅜	½	¾	1	1¼	1½	2	2½	3
Plain, each	.30	.40	.50	.60	.80	1.20	1.60	2.00	3.20	4.80
Galvanized, each	.45	.60	.75	.90	1.20	1.80	2.40	3.00	4.80	6.20

THE NEW IMICO PATENT UNION





New Imico Unions are made of non-corrosive malleable iron, extra heavy, with bronze metal valve seated disc and non-corrosive ring connection.

Size, inches	¼	⅜	½	¾	1	1¼	1½	2	2½	3
Plain, each	.30	.40	.50	.60	.80	1.20	1.60	2.00	3.20	4.80
Galvanized, each	.45	.60	.75	.90	1.20	1.80	2.40	3.00	4.80	7.40

Also Mfgr's of

MALLEABLE and CAST IRON FITTINGS

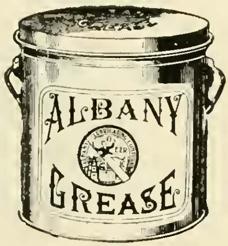
Write for Catalogue

ALBANY LUBRICATING CO.

ADAM COOK'S SONS, Props.

708-710 Washington St., NEW YORK, N. Y.

ALBANY GREASE FOR THE LUBRICATION OF ALL KINDS OF MACHINERY, ESPECIALLY LUBRICATION WITH INFREQUENT ATTENTION. COOK'S LUBRICANT FOR EFFICIENT AND ECONOMICAL LUBRICATION OF GEARS OF ALL KINDS.



ALBANY GREASE

Albany Grease is a pure lubricant so compounded that it automatically maintains a film of oil between rubbing surfaces, reducing friction losses to a minimum. It contains no adulterants and is guaranteed not to oxidize, gum or corrode the metal of the bearings. Made in different consistencies to meet different temperature conditions.

SOFT NUMBERS (Nos. 0 and 1) for cold and extremely cold conditions such as outdoor use in winter.

MEDIUM NUMBERS (Nos. 2 and 3) for moderate, warm and summer weather use.

HARD NUMBERS (Nos. X, XX, XXX) for use in hot boiler and engine rooms, etc.

There is an Albany Grease to meet all needs. Tell us your requirements and we will recommend the right number.

COOK'S LUBRICANT

Cook's Lubricant is especially adapted for lubricating gears of every kind. It possesses a remarkable tenacity. No matter how fast or slowly the gears are running, a film of lubricant is always maintained between the meshing teeth.

Cook's Lubricant will not run or leak out of the gear case; it cannot be thrown off the gears by centrifugal force; it will not drip from the gears and settle in the bottom of the gear case; it cannot be cut up and packed aside by the gear teeth in action, and is not affected by changes in temperature.

Due to the wide publicity given Albany Grease and Cook's Lubricant, unscrupulous concerns occasionally substitute inferior goods for our products. When purchasing Albany Grease or Cook's Lubricant, insist that our trade mark appear on package.

ALBANY LUBRICATING COMPOUND

COOK'S AUTO TRANSMISSION LUBRICANT

Write for literature or detailed information covering our lubricants.

DETROIT LUBRICATOR COMPANY

DETROIT, MICH.

MANUFACTURERS OF LUBRICATORS, FORCE FEED OILERS, OIL AND GREASE CUPS, AIR AND GAUGE COCKS, PRIMING CUPS, BALANCED THROTTLE VALVES, WATER GAUGES, POP SAFETY VALVES, FUSIBLE PLUGS AND RADIATOR VALVES.

DETROIT SIGHT FEED LUBRICATORS

Detroit Lubricators are made in a sufficient variety of styles and kinds to properly lubricate the valves and cylinders of all types of steam engines, steam pumps, gas engines, air compressors, etc. The complete line includes 146 styles and sizes of lubricators—one for every kind of service.

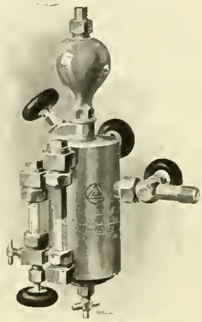
IMPROVED STANDARD LUBRICATOR

Double Connection

For use on all kinds of steam engines, steam pumps, etc.

Installed with both connections between the boiler and the throttle.

Finished in polished brass or nickel plated.

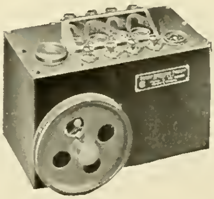


Size	1/3 Pt.	1/2 Pt.	1 Pt.	1 Qt.	1/2 Gal.	1 Gal.
Pipe Thread on Support Arm	1/2	1/2	1/2	1/2	3/4	3/4

DETROIT FORCE FEED OILERS

Detroit Force Feed Oilers are designed for the mechanical lubrication of gas and gasoline engines, air compressors, etc. The advantages of this system of lubrication are: cool, clean oil forced by mechanical pressure and in quantities as needed to the proper point to be lubricated, the elimination of the possibility of injury from running dry or carbon deposits, and very little attention from the operator as there is only one tank to fill.

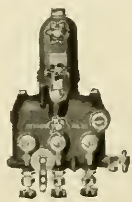
They are made with 1 to 30 feeds and corresponding capacities of 3 to 18 pints, using a standard tank, $4\frac{3}{8}''$ wide and $5''$ high. Special models for gas tractors, marine and stationary engines, automobiles, commercial trucks and aeronautical motors.



Four Feed Force Feed Oiler

DETROIT LOCOMOTIVE LUBRICATORS

Detroit Locomotive Lubricators are thoroughly suited to fulfill all the requirements of every style of locomotive from the saturated simple engine to the most modern superheated Mallet. The No. 22 Type of Bullseye Lubricators is recommended as possessing improvements and refinements made desirable by the needs of modern locomotive practice, resulting in a low cost of maintenance and economy in oil. Made with from one to eight feeds.



Three Feeds
Three Pints Capacity

DETROIT RADIATOR VALVES

Detroit Radiator Valves embody in their design the results of years of experience in the manufacture of all kinds of valves for all styles of heating installation. The Detroit Packless Valve fulfills the need for a radiator valve that will not leak around the stem nor need repacking. Its construction makes it perfectly adapted also for use in vacuum systems where tightness is essential.

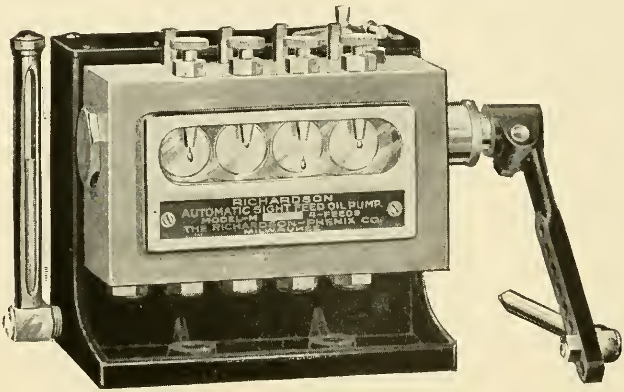
Packless

THE RICHARDSON-PHENIX CO.

126 Reservoir Ave., MILWAUKEE, WIS.

LUBRICATION ENGINEERS AND MANUFACTURERS

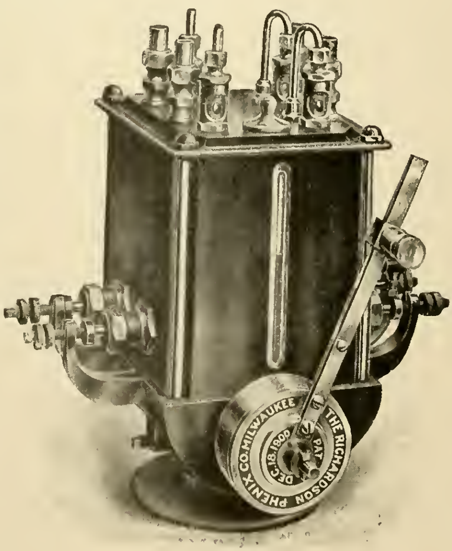
THE RICHARDSON SIGHT FEED LUBRICATOR



operates on a new principle in that it supplies oil for cylinder lubrication in small particles for every stroke of the engine piston. Built in sizes of from one to twenty-two feeds and if desired can be furnished subdivided to handle two or more kinds of oil. Fully illustrated and described in catalog No. A-53.

PHENIX LUBRICATOR OIL PUMPS

These lubricators are especially adapted to the librication of high-speed engines, all power plant auxiliaries, steam hammers, dredges, hoisting and traction engines, etc. Built in sizes from one to twelve feeds, square type and one to two feeds, round type. Can be furnished with divided tanks if desired. Salient Features: Delivers oil against any pressure up to several thousand pounds—at any lever stroke from $\frac{1}{4}$ to 7 inches regardless of changes in temperature or viscosity of oil or length of feed line. Fully illustrated and described in catalog No. A–54.



THE RICHARDSON-PHENIX CO.

126 Reservoir Ave., MILWAUKEE, WIS.

LUBRICATION ENGINEERS AND MANUFACTURERS

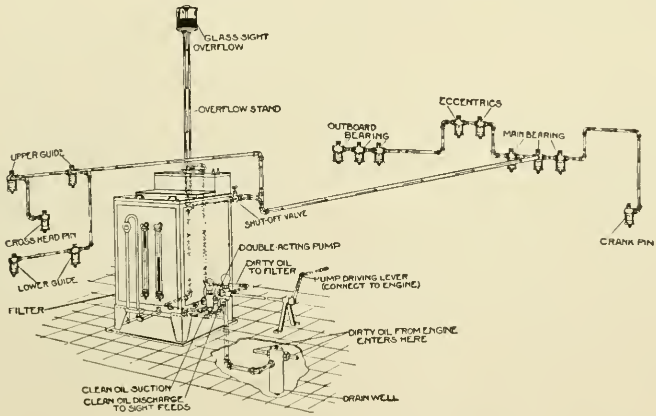
CENTRAL OILING SYSTEMS

We advise and quote on the necessary material and apparatus or design and install complete Automatic Cylinder and Bearing Lubrication Systems, in which the oil is regularly and positively supplied in just the proper quantities and, in the case of bearing lubrication, is filtered and used over and over again.

Our experience in this work, extending over a period of many years, has placed us in possession of valuable data on this subject and there is hardly a question pertaining to machinery lubrication that we have not met and solved.

We would be pleased to correspond with those interested in reducing lubrication expenses, with a view of explaining our proposition in greater detail.

INDIVIDUAL OILING SYSTEMS



Complete Richardson Individual Oiling System

RICHARDSON AND PHENIX INDIVIDUAL OILING SYSTEMS do away entirely with the necessity of installing overhead storage tanks, filters buried in the basement, or long lines of piping; starts and stops with the engine or machine to which it is applied and the entire system is always in sight of the engineer.

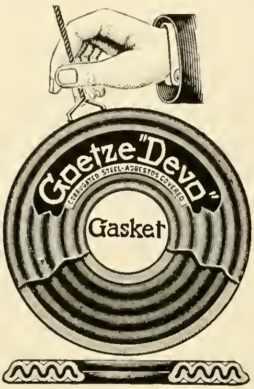
Salient features—low first cost, simplicity, efficiency, reliability.

Can be applied to any size and type of engine or power plant auxiliaries from 5 to 5,000 h.p. Fully illustrated and described in our 50 page Book A–55, "Scientific Lubrication of Machinery" which also contains the latest information on the application, use and selection of oils for all power plant purposes.

GOETZE GASKET AND PACKING CO.

22 ALLEN AVE. NEW BRUNSWICK, N. J.

METAL GASKETS OF VARIOUS TYPES. METALLIC ENGINE PACKING. SHEET PACKING FOR FLANGES. VALVE GASKETS OR DISCS.



DEVO GASKETS

These are made of corrugated steel covered with asbestos which in turn is covered with graphite.

They are intended for use in connection with high pressure, superheated and saturated steam and other unusually severe conditions and will hold tight against extremes of pressure and temperature.

Devo Gaskets appeal to every practical engineer because they are indestructible and low in price.

Every Devo Gasket is guaranteed for five years and will be replaced within that time if found unsatisfactory.

GOETZE NO. 2 ELASTIC GASKET

A Copper-Asbestos Gasket—the copper is corrugated and the closely twisted asbestos is held in the corrugation as shown in the cut at the left.

While unlike the Goetze Devo Gasket in construction, it is also recommended for high pressures, high temperatures and the most exacting service generally.

When used for flanges, it makes a joint practically as leak proof as the pipe itself, even with the roughest, most uneven surfaces.

Guaranteed for five years and sent on 90 days' trial.

GOETZE'S VALVE GASKETS OR DISCS

These are intended for valves of the Jenkins type and are made of copper and asbestos. The illustration shows a plan and section and it will be noticed that the hole has two flat sides as is common in most makes of valve discs. They are made in the following sizes: $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, 6, 7, 8, 9, 10 and 12 inches.

THE AJAX METAL COMPANY

PHILADELPHIA, PA. BIRMINGHAM, ALA.

AJAX GENUINE AND BULL BABBITT AND AJAX BULL RING METAL.

AJAX BULL BABBITT

TRADE MARK

We have given this name to a special brand of Babbitt Metal made exclusively by our Company; it is always poured into ingots, having on their upper faces the impression of a bull's head.

This metal was designed for general purposes and answers in most cases where genuine babbitt is being used.

It costs only about one quarter as much as genuine and will mostly do better work.

It can be used for all bearings except those carrying an extremely heavy load, and will run cool at any speed.

AJAX GENUINE BABBITT

This is a tin-base babbitt of high tin content which can be thoroughly recommended for bearings of large diameter (over 3″) and in which a thin shell of babbitt is used. It works perfectly for bearings which sustain heavy loads, has a high compressive strength, and is very much tougher than the lead-base babbitts. It positively will not crack, and for severe duty it is unsurpassed.

TESTS

Samples of Genuine and Bull Babbitt submitted to friction, compression and analytical tests, gave the following results.

Brand	Friction in Pounds, Total	Temp. above Temp. in Room, in deg. F.	Loss in Weight by Wear in giving	Genuine Babbitt Tin 89—Copper 4—Antimony 7 Used as Standard 1			Coefficient of Friction	Melting Point Deg. Centigrade	Specific Gravity approximately	Compression at Yield Point
				Relative Friction	Relative Wear	Relative Temperature				
Genuine	18.5	44	1.30	1	1	1	.0088	220	7.3	17600
Bull	20.5	50	1.20	1.10	.92	1.13	.0097	226	10	12100

Speed: 310 rev. per min. *Total number of rev.:* 1,000,000. *Pressure per sq. in.:* 600. *Total:* 2100. *Area surface of contact:* 3 1/2 sq. in. *Journal:* 3 3/4″ diam., 3 1/2″ long. *Lubrication:* One drop of oil per min. *Remarks:* Metal cast direct into pieces used for tests.

AJAX BULL RING METAL

This has been brought out to meet the demands for an antifriction metal that will reduce the friction and consequent wear and scoring of engine cylinders. It is now generally conceded that excessive wear results from cast iron bull rings working in engine cylinders of like metal. Our Bull Ring metal besides having excellent antifriction qualities has a melting point sufficiently high to meet the thermal conditions of the cylinder and a coefficient of expansion about equal to cast iron.

Our metals are all made in a modern plant, under chemical supervision, and by skilled workmen; and we guarantee them to run absolutely uniform.

LUMEN BEARING COMPANY

BUFFALO — TORONTO

BRASS FOUNDERS

We will be pleased to offer specific information to engineers, concerning the alloys here enumerated. These alloys are in constant demand, having been designed particularly for engineering purposes.

Alloy No. 00, A, B, and C.	For extremely heavy pressures. (1/32″ deflection at 100,000 lb. under test.)
Alloy No. 0	For acid resisting construction.
Alloy No. 1	For same service as "G" bronze Navy Department, Bureau of Steam Engineering.
Alloy No. 3	For steam engine slide valves.
Alloy No. 4	For bearings at high speeds and under heavy pressures. The standard phosphor bronze for bearing purposes.
Alloy No. 8	For electrical purposes. Pure copper; conductivity about 85.
Alloy No. 9	Manganese bronze. Tensile strength 70,000 to 75,000. Elongation (2″) 20% to 25%.
Alloy No. 14	For lathe head stocks. A bronze having the lowest co-efficient of expansion of the copper-tin alloys.
Alloy No. 15	For gears under severe service.
Lumen	For machine tool bearings. Compressive strength 85,000 pounds.

LUMEN BEARING COMPANY · BUFFALO-TORONTO · TRADE MARK REGISTERED

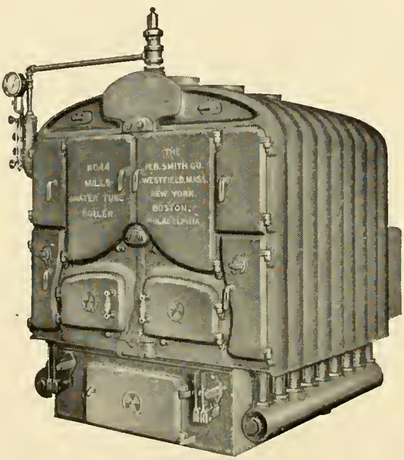
THE H. B. SMITH CO.

WESTFIELD, MASS.

NEW YORK — BOSTON — PHILADELPHIA

BOILERS AND RADIATORS FOR STEAM AND WATER WARMING

MILLS WATER TUBE BOILERS



No. 44 Steam Boiler

No. 24 Boiler
Width of Fire Pot 24 inches.
Rated capacity: Steam 900 ft. to 2025 ft. Water 1500 to 3350 ft.

No. 34 Boiler
Width of Fire Pot 34 inches.
Rated capacity: Steam 2000 ft. to 5200 ft. Water 3300 ft. to 8575 ft.

No. 44 Boiler
Width of Fire Pot 44 inches.
Rated capacity: Steam 3600 ft. to 9000 ft. Water 5950 ft. to 14,850 ft.

No. 48 Boiler
Width of Fire Pot 48 inches.
Rated capacity: Steam 4800 ft. to 12,000 ft. Water 7925 ft. to 19,800 ft.

Vertical Water Tubes.

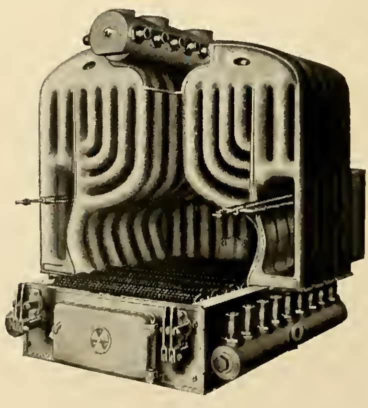
Vertical Fire Travel.

Tested to 125 lbs. at Works.

Rapid Circulation.

Dry Steam.

Economy of Fuel.



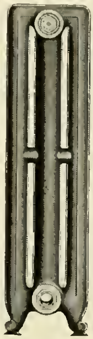
No. 44 Boiler—Interior

THE H. B. SMITH CO.

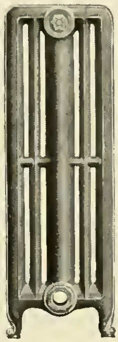
PRINCESS DIRECT RADIATORS

Single Column

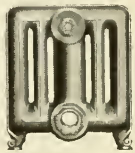
Two Column



Three Column



Five Column



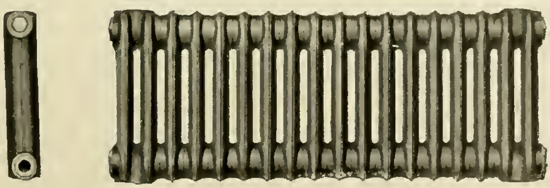
Five Column Window Height

Malleable Iron Push Nipple connection between Sections.

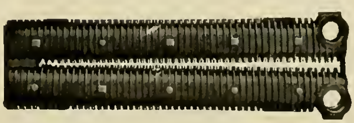
Test at Factory { Two tests 100 lbs. water. One test 80 lbs. steam.

One and two column Radiators, Sections 3″ on centers.

Three and five column Radiators, Sections $3\frac{1}{4}$″ on centers.



PRINCESS WALL RADIATORS



Flange Surface

Indirect Radiators

FLANGE AND PIN EXTENDED SURFACE

for

STEAM AND WATER WARMING.

THE PETROLEUM IRON WORKS CO.

SHARON, PA.

NEW YORK — ST. LOUIS — HOUSTON, TEXAS

FABRICATORS AND ERECTORS OF EVERY VARIETY OF LIGHT AND HEAVY STEEL PLATE CONSTRUCTION.

TANKAGE FOR ALL PURPOSES LARGE OR SMALL; OIL REFINERY EQUIPMENT, STAND PIPES, WATER TOWERS, SMOKE STACKS, PENSTOCKS, RIVETED STEEL PIPE, BLAST FURNACES, HOT METAL LADLES, BOILERS, ANNEALING BOXES, "LEMAN" COUNTER CURRENT CONDENSERS, "GEM" FUEL OIL BURNERS, "WASHINGTON" AUTOMATIC OIL AND GAS SEPARATORS, PORTABLE RECEIVING TANKS, CAR TANKS ETC.

The Petroleum Iron Works Company is located on a property of forty acres, situated about three miles south of Sharon, Pa.

Our railroad facilities here are excellent, as the works have direct connections with the New York Central, the Erie and the Pennsylvania Railway Systems. Our trackage for receiving and shipping inbound and outbound freight is more than a mile in length, thus affording ample space for car storage and ideal facilities for making shipments. Car shortages and delays occurring where there is but one railroad connection are practically unknown in this district. We, therefore, feel sure the trade will fully appreciate this condition, as it enables us to guarantee our promises of delivery to points in every direction.

Our present plant consists of a substantial steel structure, fully equipped with modern machinery, tools and appliances, which insure accurate and rapid production. We are now in position to give our customers better satisfaction and more prompt service than ever before. Superior manufacturing facilities and careful shop inspection will continue to maintain our long established reputation for high class work.

It is difficult to prepare a catalogue that will adequately describe and illustrate all the classes of sheet metal structures and apparatus that we are in position to furnish and erect. The illustrations presented are shown merely as types of our various lines of work, among which we might enumerate the following:

Oil Storage Tanks (large and small)
Acid Storage Tanks
Water Tanks
Water Softener Tanks
Molasses Tanks
Turpentine Storage Tanks
Grain Tanks
Tar Tanks
Hydro-Pneumatic Tanks
Pressure Tanks
Filter Tanks
Car Tanks
Portable Receiving Tanks
Railroad Water Service Tanks
Oil Refineries (complete)
"Leman" Counter Current Condensers
"Washington" Automatic Oil and Gas Separators
"Gem" Fuel Oil Burners
Riveted Steel Pipe
Flumes
Penstocks
Blast Furnaces (complete)
Converters
Hot Metal Ladles
O. H. Furnaces
Pulp Digesters
Galvanizing Kettles
Creosoting Cylinders
Condenser Boxes
Coal Bins
Steam Separators
Air Receivers
Water Towers
Stand Pipes
Smoke Stacks (Self-Supporting and Guyed)
Breechings, etc., etc.

Frequently special problems arise, and in such cases we are glad to offer the services of our Engineering Department. In order to assure prompt replies to inquiries we respectfully request complete detail information, including specifications and blue prints when possible. We hope by prompt and careful attention to our customers' inquiries to be favored with at least a portion of your valued orders.

We issue no discount sheet owing to the constant fluctuations in prices, and for the reason that practically all of our products are built to order.

THE PETROLEUM IRON WORKS CO.

OIL REFINERIES—COMPLETE

10′ x 30′ Single, Double, and Triple Compartment Cylindrical Horizontal Oil Storage Tanks ready for shipment.

150 000 Gallon Water Tower,
Yonkers, N. Y
(Height over all 184′)

R. R. Water Service Tank.
Erected East Waco, Texas, for the "Cotton Belt."

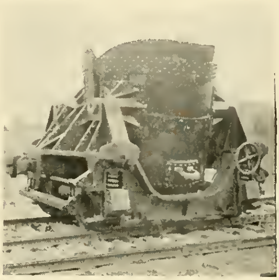
RITER-CONLEY MANUFACTURING CO.

PITTSBURGH, PA.

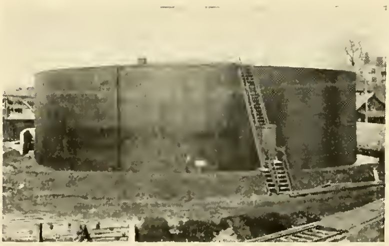
STEEL CONSTRUCTION

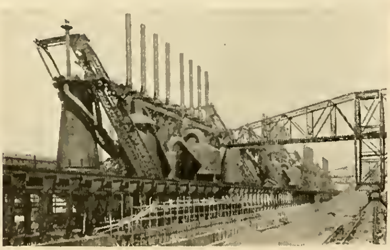
This company has splendid facilities for designing, fabricating and erecting such structures, etc., as are listed and illustrated below.

Barges
Blast Furnaces
Bridges
Buoys
Caissons
Converters
Car Tanks
Gas Holders
Gas Plants
Galvanizing Pots
Ladles
Mixers



Penstocks
Pipe Lines
Pressed Steel of every Description
Stacks
Stand Pipes
Steel Ships
Steel Plants
Structural Steel Work
Sugar Crystallizers
Tanks
Towers for Transmission Lines





ALPHABETICAL INDEX TO CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

AUGUST 1913

35 CENTS A COPY $3 A YEAR

ANNUAL MEETING: DECEMBER 2–5

NEW MEMBERS AT THE ANNUAL MEETING

To secure admission to the Society in time to participate at the Annual Meeting as a member, applications should be filed not later than August 25.

A reprint of the List of Members, arranged geographically, has just been issued. An Appendix is included which contains all additions to the membership up to July 8, 1913. Approximately five hundred new members are included in this Appendix.

Those who have been unable to complete their applications for membership through inability to name the required number of references may find the names of additional acquaintances among these new members.

A brochure containing a description of the new features of membership has also been issued and may be had upon request.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

Chairmen of Sub-Committees

Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Cleveland, R. B. Sheridan
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thos. Morrin
Seattle, R. M. Dyer

AUGUST 1913 VOL. 35 No. 8

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

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Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C 55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF

MECHANICAL ENGINEERS

VOL. 35 AUGUST 1913 NUMBER 8

The Society's stock of Volume 6 of Transactions is entirely exhausted and to supply urgent demands copies will be purchased at five dollars per volume if delivered at the Society rooms prepaid and in good condition.

THE TRIP THROUGH GERMANY

The tour through Germany of the official party of the Society was fittingly ended on July 9 at Munich, the home of Dr. Oskar von Miller, president of the Verein, and the location of the great German Museum of science and industry, the upbuilding of which has become Dr. von Miller's life work.

The last event at Munich was a banquet given by the city in the old town hall, which was built before Columbus discovered America and which is one of the most beautiful of the old continental town halls.

In its associations and surroundings this event was typical of other receptions and dinners given by the various cities or by the local sections of the Verein deutscher Ingenieure. The first was at Hamburg held in the Rathaus, or Council House. While this is a modern building, completed in 1842, it is noteworthy because of its elaborateness and beauty and is comparable with our largest state capitols, although undoubtedly much finer than any of them in an artistic sense. A similar setting was offered in the Gürzenich at Cologne, built in its original form in 1447 for festivals of the town and the scene of brilliant receptions by

Frederick III, Maximilian I and other emperors of the fifteenth and sixteenth centuries, and in the Römer in Frankfort where the local section of the Verein tendered a luncheon and reception, this being the ancient Rathaus in which were crowned the emperors of the Holy Roman Empire from Charlemagne in 768 to Joseph II in 1792.

The trip included visits to eleven cities, at each of which was accorded a reception far beyond the anticipations of the visitors. In the speeches at the banquets a splendid spirit of coöperation was voiced and a firm conviction of the power of the two great nations represented to continue in amicable industrial relations and to bring about universal peace in the larger affairs of state.

While these functions, with their historically interesting settings, were most impressive and of the utmost importance, the greatest pleasure of the trip came from the gracious hospitality of the German people and the three weeks of intimate association with them. It was very evidently a real pleasure to render the services they did to their American friends and to count them as friends rather than as mere acquaintances. Their hospitality was always genuine and at times overwhelming and it would be difficult to conceive of greater originality than was displayed in the delightful means devised for the entertainment of their guests. Repeatedly some feature was introduced which captivated the American party. Sometimes this was in the form of a musical treat such as a concert by the Leipzig symphony orchestra, singing by the famous boy choir of St. Thomas church in Leipzig, founded by Bach, and the first in Europe; singing by the men's choral society of Cologne, which has won the prize from all Germany for the past two years; the playing of the bugle corps, fifty strong, at Düsseldorf, where the buglers, with instruments hung with flags, played in a stirring manner, raising or lowering their bugles in unison at the beginning or end of each movement; or the dances by the troup of Bavarian peasants brought down from the mountains by the Munich section for their opening event.

Very often, however, the entertainment took the form of an original production applying directly to the occasion. This may have been an original song, or a monologue such as that given in a very pleasing manner by a talented young woman at Cologne just previous to the trip on the Rhine, who personified the Lorelei. The culminating feature of this kind was an allegorical

play at Düsseldorf entitled Der Ring der Arbeit. The piece was elaborately staged with a representation of the interior of a steel works. On one side was the furnace and on the other a huge steam hammer, while in the background were small forges, anvils and other apparatus. In the foreground was the representation of a full-sized ingot which shortly began to glow with heat as fire nymphs from the furnace danced around it. Workmen pushed the ingot under the hammer where it was forged to the accompaniment of an anvil chorus, and when withdrawn and displayed to the audience it had the form of a forged ring, enclosing and holding together the seals of the two societies and the letters V.D.I. and A.S.M.E., with the goddess of liberty appearing close by. Souvenirs were later presented in the form of paper-weights showing in relief the figure of the goddess of liberty and the united seals.

Throughout it was evident that the members of the Verein and their families had given personal attention to many details which contributed to everybody's enjoyment. The special train was met at the station by the local engineers and several times their wives and daughters personally distributed roses to the visiting ladies as they walked up the station platform. A similar courtesy was shown at several of the banquets, and from start to finish, wherever a touch of friendliness could be displayed or personal service rendered, it was sure to be added. This spirit was in evidence first at Plymouth where several German engineers rose at three o'clock in the morning in order to board the boat to accompany the American party to Hamburg, and continued throughout the trip up to the last day at Munich, where the directors of the German Museum presented the Society with a telescope made over 100 years ago by the famous Fraunhofer, the discoverer of the black lines of the spectrum.

The trip through Germany was primarily to observe the engineering and industrial work of the nation, and every opportunity was afforded for the inspection of the leading plants of each city. In every case the reception was cordial in the extreme and often accompanied by elaborate entertainment. Perhaps the most important visits of this kind were the inspection of the inland harbor of Hamburg and the adjacent works of Blohm and Vose, who are now building for the Hamburg-American Line the steamship Vaterland, which is larger than the Imperator. The harbor is 50 miles inland on the river Elbe and excavated almost

entirely from land adjacent to the river banks. It is the largest in Germany and has the third largest shipping trade in the world, with docks to accommodate 450 sea-going vessels and 6400 coasting and river craft. The crane-handling facilities for which the harbor is so well-known were especially interesting, and it is further worthy of note that at a single point were here observed the largest dock, the largest crane and the largest ship in construction in the world.

Scarcely less impressive were the dock facilities inspected still further inland at Duisburg and Ruhrort, constituting the facilities for traffic between the Rhinish-Westphalian coal and industrial district and the waterway of the Rhine. These harbors have a tonnage much greater than any other inland port in the world and only slightly less than that of Hamburg.

No attempt will be made at the present time to refer to the various manufacturing plants visited except to voice the report repeatedly made by the visitors of the splendid welfare and educational work very generally practised by German manufacturers.

As is well known there is a series of insurance laws in Germany requiring provision to be made for the insurance and pensioning of employees and for other features calculated to contribute to their comfort and happiness. Many concerns, however, go far beyond the actual requirements of the law and provide ideal housing arrangements, medical attention, convalescent homes, and factory conditions, which in cleanliness and general attractiveness are almost ideal. The German laws further provide for the instruction of young men who have left school in the intermediate grades, until 18 years of age, usually by means of a night school, and manufacturers now are providing apprentice courses in this connection in which instruction is given in the trades in separate departments and with it the required amount of schooling, but during working hours instead of in the evening.

At Leipzig were the two professional sessions of the Verein deutscher Ingenieure in which The American Society of Mechanical Engineers participated. The first, held in the Central Theater, was a brilliant event attended by the engineers of both nations, occupying the main floor, and the ladies who occupied the balconies. The meeting was honored by the presence of King Friedrich August of Saxony and by many noted men in engi-

neering and science, among them Count Zeppelin. The papers presented were Technical Science and Culture of the Present by Professor Lamprecht, and Engineering Development and Modern Welfare by Dr. W. F. M. Goss, President of The American Society of Mechanical Engineers. At this session honors were conferred upon George Westinghouse.

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Along with the technical features of the journey were several pleasure trips that were welcomed by the visitors as forming a break in their strenuous journey. At Leipzig there was a delightful trip to the Bastai in Saxon-Switzerland on the river Elbe. Here the guests participated in a little mountain-climbing among the high sandstone formations which give the name to this range of hills. From Berlin the party was taken in unusually fine sight-seeing automobiles to the Havel river several miles out, beyond Charlottenburg, where a steamer was boarded for a sail through the picturesque Havel lakes into which the river expands. The steamer was accompanied by a launch carrying a bugle corps alongside to render music, which was much more pleasing than where the band is on the boat itself. A landing was made at the beautiful country-seat of Herr Carl F. von Siemens for participation in a garden party on his spacious grounds, handsomely decorated for the occasion. There was a pleasing entertainment by a choral society from the Siemens and

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Preceding the dedication the Dean of Westminster paid a short tribute to Lord Kelvin, dwelling upon the extraordinary group of Cambridge men with which he was associated, all of whom had not only a good head but a good inheritance. It had been the part of Kelvin to transform to the practical utility of mankind the glories of the new fields of knowledge opened up in the Victorian era and the new world of electricity which had been discovered. He was never spoilt by fortune in the pursuit of his researches and never allowed himself to be a recluse; he was always genial and accessible, always humble and unselfish. Nothing was too simple for his experiments, nothing too abstruse for the powers of his calculation. All through his life, in the

face of the strong prevailing current of materialism, he preserved the simplicity of his early Christian faith. He spoke with humility of a great man and many could look back with gratitude upon the influence of the example of his religious belief which a man of his gigantic intellect furnished to those of a younger generation. One of the inventions which his genius succeeded in perfecting was that for submarine telegraphy across the Atlantic, and Englishmen and their American brothers had thereby been brought into immediate, constant and almost instantaneous communication, and a sense of brotherhood, whose peace had been unbroken for one hundred years and which it was to be hoped would so continue, had been materially deepened and strengthened. Kelvin's name on both sides of the Atlantic was one of the most epoch-making in the domain of natural philosophy.

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Cajander, Sven Gottfrid, Chile, S. A.
Chadwick, George Albert, Alexandria, Va.
Clarke, Walter J., San Francisco, Cal.
Conti, Angelo, Washington, D. C.
Cook, Charles Bannister, Hartford, Conn.
Courtenay, Charles R., Watertown, N. Y.
Fortney, Camden Page, Gatun, C. Z.
Frick, John, Philadelphia, Pa.
Gibson, Frederic Arthur, Huddersfield, England
Haines, Philip G., Rochester, N. Y.
Hardesty, Frederick Sawyer, Washington, D. C.
Henley, Wm. Wheeler, Tucson, Ariz.
Hogg, James, Amsterdam, N. Y.
Hopkinson, Joseph, Dayton, Ohio
Kugel, H. K., New York, N. Y.
Lynn, Thomas H., Williamsport, Pa.
Menzin, Abraham Louis, Edge Moore, Del.
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Hopkinson, Joseph, Dayton, Ohio
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EFFICIENCY OF ROPE DRIVING AS A MEANS OF POWER TRANSMISSION

By E. H. Ahara

ABSTRACT OF PAPER

This paper deals with a series of tests on transmission of power by rope drives under various conditions. The efficiency is measured under full, three-quarters, one-half and one-quarter loads. One inch best manila rope was used. The test covers drives of from one to eight ropes, with centers from 25 to 150 ft., on both American and English systems.

Tests also covered open, or straight drives, as well as indirect, or up and over drives.

The efficiencies as shown indicate a greater efficiency in the American than the English system. Medium speeds, though showing less capacity, show a greater efficiency than high speeds.

Accurately turned sheaves show a decided gain over ones that vary in pitch diameter; and direct drives are always preferable to the indirect ones.

The efficiency of rope driving does not materially vary over a wide range of different working tensions in the rope.

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By E. H. Ahara, Mishawaka, Ind.

Member of the Society

Of the several types of mechanical power transmission including belting, gearing, rope driving, etc., the question of efficiency of the last has perhaps received the least attention and, outside of general treatment, very little engineering literature, considering the importance of the subject, is obtainable. While transmission by rope systems of various kinds is a very old method of transmitting power from one shaft to another, being used, according to one authority to a limited extent by C. F. Hern, of Logleback on the Rhine, Germany, as early as 1852, the difficulty of obtaining accurate measurements of the power consumed by the rope itself has prevented its efficiency being easily ascertained in practical work. Because of the ease with which electrical measurements can be taken by means of direct reading instruments, which enabled power consumption to be measured so much more readily than by any other means, electrical power itself has been given much more attention than other types of power service.

2 Owing to there being no way of determining the losses in transmission in regular working rope drive installations, the efficiency can be ascertained only by laboratory, or test outfits, and these, considering the diversity of types and methods, the large number of variables involved, as well as the vast difference in working conditions and capacities, are necessarily elaborate and the expense of such tests has tended to limit the knowledge obtainable in this way. The present tests were undertaken with the object of obtaining, in a practical way, some definite figures on a few of the several variables in rope-driving practice, and

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it is believed that the plan is broad enough in its scope to give reliable data whereby the efficiency of most drives may be very closely approximated.

3 The importance of the tests may be estimated from the conclusions that are deducible from the data obtained. They seem to show that the efficiency in rope driving is considerably greater at the lower speeds than at the higher ones, the dropping off being especially noticeable above 4500 ft. per min. of rope speed. They also show that the efficiency of a rope drive is not materially affected by distances between centers up to 150 ft., that the drop of efficiency at 50 per cent load is comparatively small over that of full load, and that if proper care is exercised to have all grooves perfect in pitch diameter many as well as few ropes can be run on a drive with good efficiency. With the American system, increasing the slack rope tension up to 360 lb. in a 1-in. rope does not appear to decrease its efficiency, but rather to increase it if power is used in conformity with this tension; but only such tension should be used as is necessary to drive the load needed. For the rope tested the American system has very much more capacity than the English system, and has also a higher percentage of efficiency. In general it would appear that, where there is a considerable power to be transmitted, the properly worked out rope drive gives a most efficient and economical method, and where conditions are favorable to its installation no other known method of transmission will so well conserve power losses.

4 There are two general systems of rope driving in common use: (*a*) the English system, the oldest, which uses a series of separate ropes, each spliced up into an endless band and occupying a separate groove on the face of each of the sheave wheels; and (*b*) the American system, the more modern, patented in the United States by W. H. Dodge, June 23, 1885, which uses one continuous rope wound about the driver and driven sheaves with a loop taken over a weighted tightener wheel, that keeps a definite tension continually in the ropes. Wire ropes or cables are sometimes used, but so rarely that no attempt was made to study their efficiency. Manila fiber ropes, which are used almost entirely in rope transmission work, were used exclusively in these tests.

5 These two general systems were tested in open drives of from one to eight ropes each under speeds of rope travel from 2500

ft. per min. to 5500 ft. per min., on center distances varying from 25 ft. to 150 ft. and with varying loads. Difficulty was found in handling the English system on 125 ft. and 150 ft. centers on account of the slack rope, which was the upper one, sagging down through the tight ropes and rubbing on the ground. This limited the work on the English system to 112 ft. centers as the maximum. Other than this limit, and the fact of varying tensions on the 100 ft. centers, the English test followed the same schedule also.

6 Both English and American systems were also tested on what is termed "up and over" drives, i. e., with four idlers, on approximately 100 ft. centers with the same approximate speeds as above, and with from one to eight ropes. There were also tests taken on the American system to determine the efficiency and capacity under different strains in the pulling rope. In all about 700 tests were taken with upwards of 7000 readings. The tests were all taken in the open air, at the plant of the Dodge Manufacturing Company, Mishawaka, Indiana, and extended over a period of five months of continuous work, ten hours a day, from August to December 1912. But few days were lost during the entire series of tests and these only on account of rainy weather.

7 The general method of conducting the test embraced the use of a 250-h.p. Westinghouse direct-current motor driving through an auxiliary rope drive to a jack shaft on which was mounted the 60-in. test driver; the driven shaft was fitted in bearings on a movable tower, and on the driven shaft was mounted the receiving sheave, of the same diameter as the driving sheave, and also a prony-brake wheel. Fig. 1 is a view of the equipment in operation with sheaves at 50 ft. centers and carrying seven ropes at 4500 ft. per min. on the American open-drive system, at a time when 155 h.p. was being transmitted. The test outfit included also a Weston standard volt meter, a Westinghouse milli-volt meter with 750 ampere shunt, a Schaeffer and Budenberg hand tachometer with three scales, two hand revolution counters, and a standard Fairbanks platform scale.

8 In taking a test one observer recorded the electrical consumption, the polarity being reversed and the average voltage taken; another applied the brake and kept the load constant; a third recorded the revolutions of the driven shaft; a fourth recorded the revolutions of the driver, and still another observed

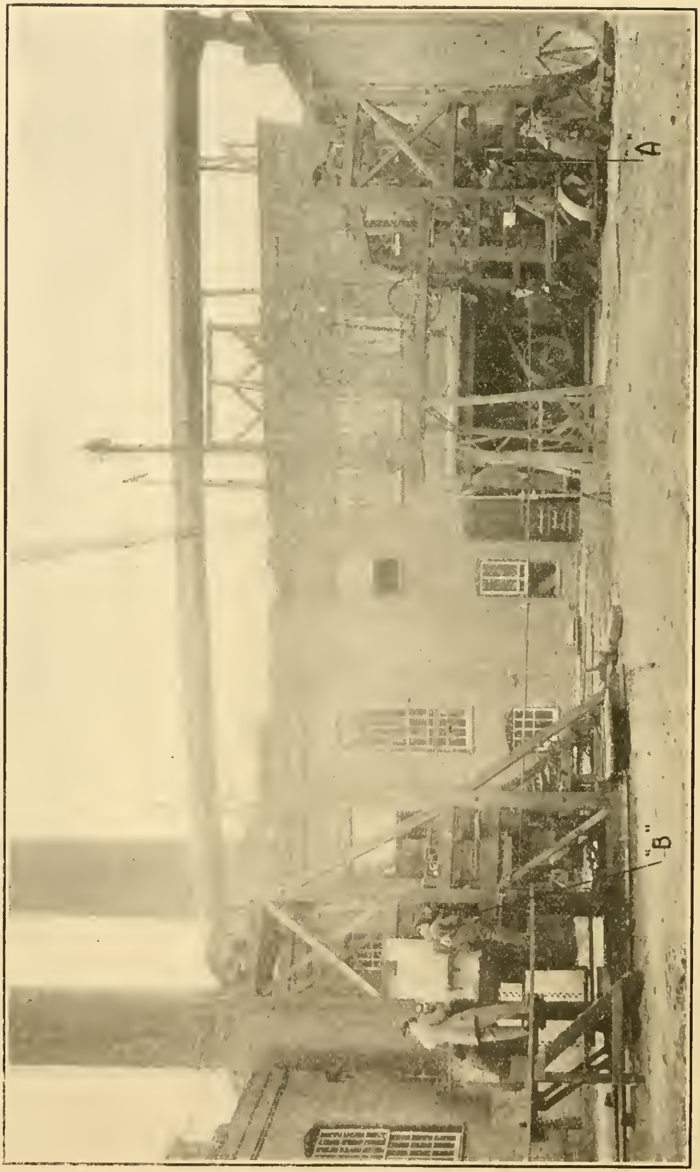

Fig. 1 Arrangement of Apparatus, American Open Drive, 50 Ft. on Centers, Seven Ropes, 4500 Ft. per Min., 155 H.P.

the sag of the rope in the center of the span. By means of electrical signals all observations were started at the same instant to avoid the effect of continual slight variations; if there arose any reason for doubt of a test being correct it was repeated. The ammeter used was compared weekly with a carefully calibrated test instrument and found to maintain its accuracy during the test. The volt meter was frequently checked by another

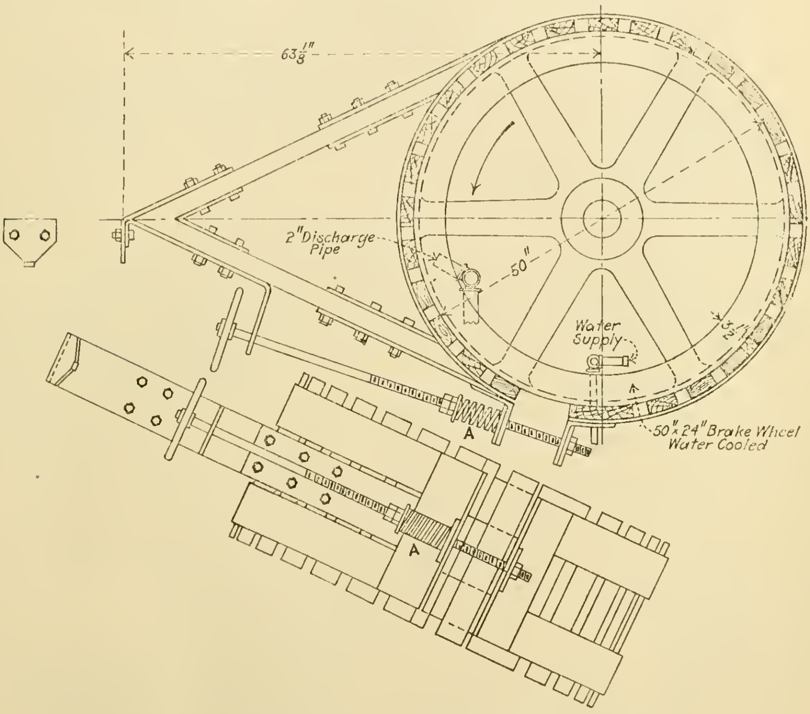

Fig. 2 Details of Prony Brake used in Tests

constantly in circuit on the main switchboard. The start was made by means of a water rheostat which was cut out by a knife switch when the motor reached full speed.

9 Owing to the large variations needed in loading on the prony brake the load measurements were taken directly on a platform scale, careful corrections being made for the weight of the prony-brake lever; also the latter was made of such length that $\frac{\text{Wt.} \times \text{r.p.m}}{1000} = \text{h.p.}$ The brake wheel was flanged so as to

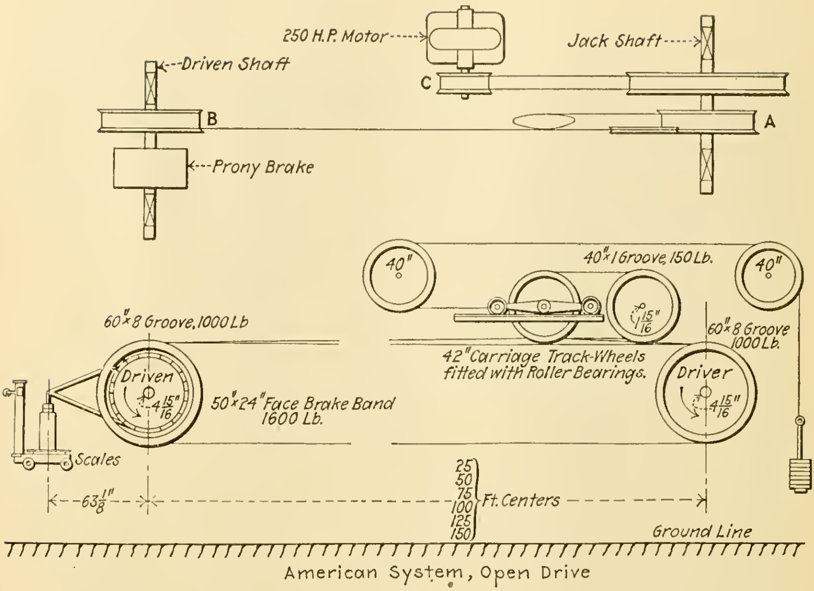

FIG. 3 GENERAL PLAN OF AMERICAN OPEN DRIVE SYSTEM

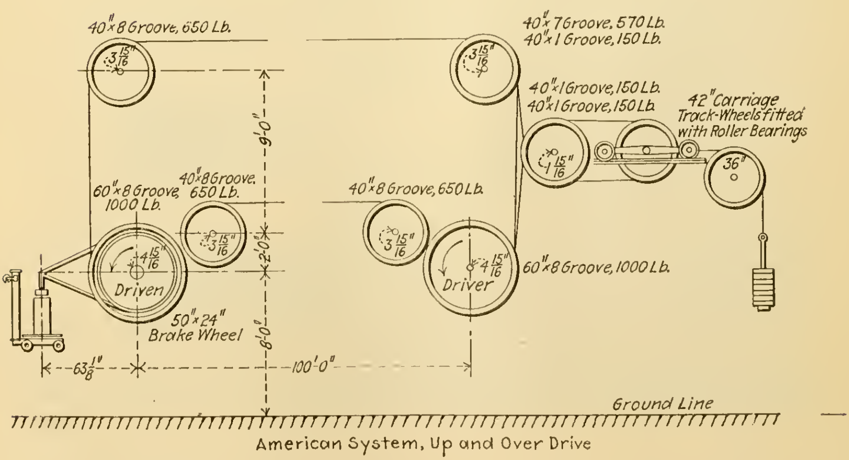

FIG. 4 GENERAL PLAN OF AMERICAN "UP AND OVER" DRIVE SYSTEM

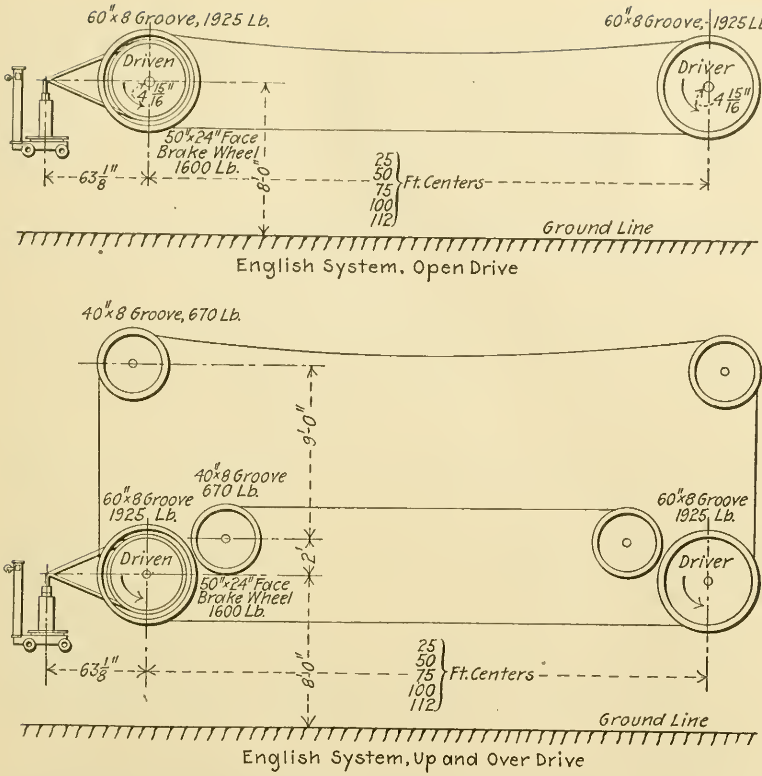

FIG. 5 GENERAL PLAN OF ENGLISH OPEN DRIVE AND "UP AND OVER" DRIVE SYSTEMS

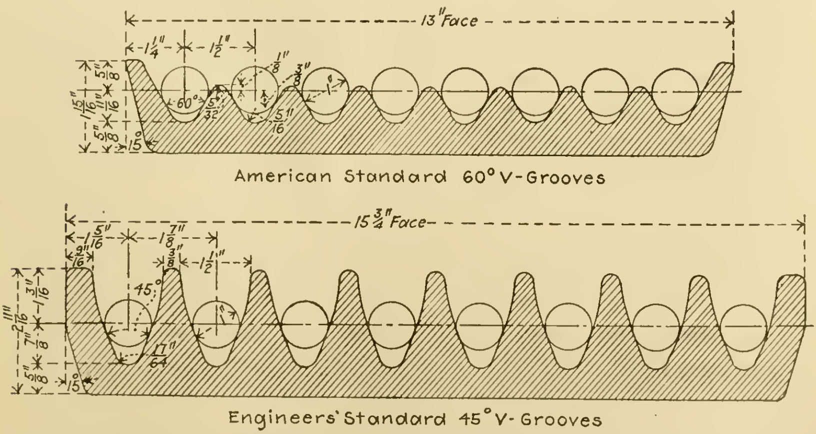

FIG. 6 DETAILS OF AMERICAN AND ENGLISH TYPES OF GROOVES USED ON DRIVER AND DRIVEN WHEELS

hold a considerable quantity of water on the inside of the rim while running, and cooling water was constantly supplied from a city water main, through a 1-in. pipe, and carried away through a 2-in. pipe; the quantity used being varied by means of a valve to suit conditions. The surface of the brake wheel was well lubricated, and having a brake band faced with cross bars of hard maple, no particular difficulty was experienced in working the brake up to 250 h.p. A spring used in the brake pressure connection at *A*, Fig. 2, prevented sudden seizing of the brake band and aided in keeping the scale load uniform. By using a proper capacity of spring, the tension of which could be varied by the screw adjustment, very good results were obtained.

10 The general plan of the American open drive is shown in Fig. 3, of the American "up and over" drive in Fig. 4, and the English open and "up and over" drives in Fig. 5. In Fig. 6 are given the details of the American and English types of grooves used on driver and driven wheels. All idler or carrier wheels used had U-shaped grooves into which the rope bottomed without side friction. The weights of all wheels, as well as dimensions, are given to afford some idea of the inertia. All bearings on all shafts were ring oiling bearings except those on the carriage axle which were ordinary grease bearings.

11 The different speeds were obtained by changing the sheaves on the motor and jack shafts and for convenience sheaves were used in pairs that gave respectively 2500 ft., 3500 ft., 4500 ft., and 5500 ft. of rope travel per minute. In order to eliminate the factor of friction of the motor itself and the jack shaft, with intervening drive, every test was started by first applying the prony brake to the jack shaft, and taking readings to determine the friction load of the motor and jack shaft under the various loads and with the various speeds of jack shaft as were to be used in the rope-drive tests later. The prony brake was then removed to the receiving shaft and the test proper carried through. Again, at the close of these observations, the brake was applied to the jack shaft and the friction readings again taken for comparison with the friction readings taken at the beginning of the test. These data were tabulated and charted, a sample of the tabulations for one set of conditions, namely, the American system, open-drive, operated with six ropes

at the 2500 ft. speed, being shown in Table 1; this gave a measured output of 945 lb. on the brake at 156 r.p.m., or 147.4 h.p., the electrical readings being 262 volts and 101.7 amperes, which equals 133,227 watts. Then by applying a load such as to cause a corresponding electrical reading with the brake applied to the jack shaft, the input to the drive was found to be 153.4 h.p. Comparisons of input horsepower as given in column 13, Table 1, and delivered horsepower as given in column 9 gives the efficiency as recorded in column 14, which is 96.1 per cent in this case.

12 The efficiency as above given includes the losses in the rope itself, the friction in the bearings on the driven shaft, and the losses due to the inertia of the driven wheel and the prony-brake wheel, and, also, in the American system the friction of the tension equipment. All tests were made to include the friction of the receiving shaft and bearings as it was thought this would more nearly approximate working conditions and make the data obtained of more general application in ordinary comparisons. All bearings used were of the ring oiling babbitted type, and the ropes were all 1-in. manila rope of best quality, carefully treated with a rope dressing to prevent the entrance of moisture and to keep the surface in as nearly uniform condition as possible. It was found during the test that this was of great importance as very slight changes in the rope surface immediately affected its capacity and efficiency.

13 The same rope was used throughout the American open drive test, the tests being run in such order that the rope was shortened at each succeeding test, and thus there was never more than one splice in the rope, thereby reducing any inaccuracy from lack of uniformity in the splice of the rope to the least possible point. This same care was observed in all of the tests, no rope being used with more than the necessary single splice, and these were in every case carefully made. Frequent photographs were taken showing the positions of the ropes under varying conditions, speeds and centers, which gave a very good idea of the test as it proceeded.

14 Fig. 7 gives the results obtained in the American open drive test for six ropes 50 ft. centers with efficiency plotted against speed; Fig. 8, the results of efficiency relative to varying centers, seven ropes at the 4500 ft. speed, and Fig. 9, efficiency relative to number of ropes for 50 ft. centers at the 4500 ft. speed.

TABLE 1 METHOD OF TABULATION OF DATA

TEST ON ROPE DRIVE EFFICIENCY

AMERICAN SYSTEM—OPEN DRIVE

DATE, 9-30-12

No. of Ropes	Speed of Ropes	Wt. on Take-up	Sheave Centers	Sag of Rope		Prony Brake			Electrical Reading			Net H.P. Consumption Compared with Prony Brake	Efficiency	Remarks
				Tight	Loose	Weight	Revolutions	H.P.	Volts	Amperes	Watts			
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15
6	A	360 lb.	50′-0″	3″	7″	945	156	147.9	262	101.7	133227	153.4	96.1	

15 It will be seen that a lower efficiency is shown on the lower number of ropes. This is undoubtedly caused by the fact that the eight-grooved wheel made for testing eight ropes was used for all the lesser number of ropes to avoid the expense of making additional wheels with a suitable number of grooves for each drive. This together with the weight of the prony brake increased the proportional friction on the smaller loads, and

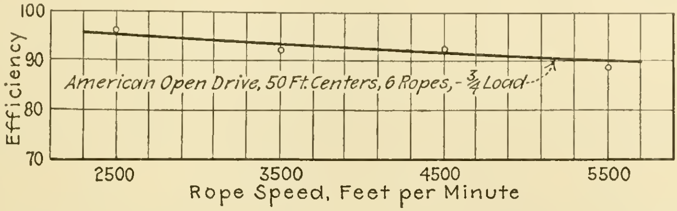

Fig. 7 Results obtained in American Open Drive Test with Efficiency plotted against Speed

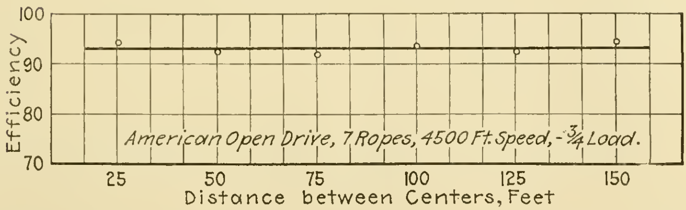

Fig. 8 Curve showing Efficiency Relative to Varying Centers

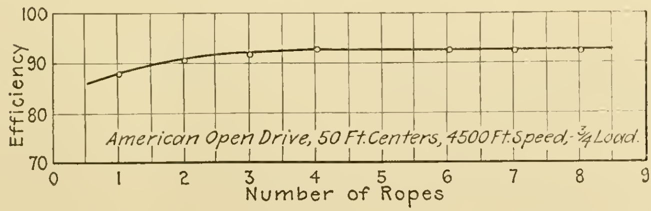

Fig. 9 Curve showing Efficiency Relative to Number of Ropes

is, therefore, a larger percentage of the total load in the drive of few ropes. With the friction of driven shaft eliminated, limiting the losses to those in the rope alone, it is believed the efficiency in a single rope would be as great if not greater than any multiple thereof.

16 All readings were taken at four different capacities. The rope was brought up to speed, and the brake gradually applied

until the observation of r.p.m. on the driving and driven shafts showed a slippage, when the brake pressure was released a trifle and the observation called "full load" taken. By changing the brake, 75 per cent, 50 per cent and 25 per cent of this load was also observed. Fig. 10, which is a good representative case, gives the comparisons of efficiency with these

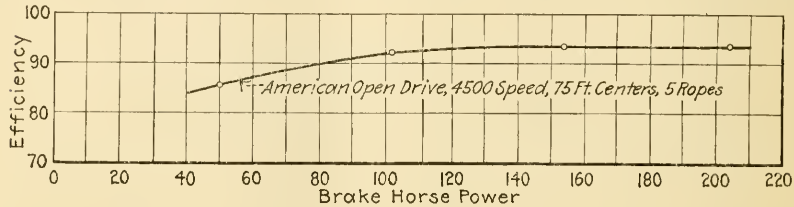

Fig. 10 Curve showing Comparison of Efficiency with Various Loads

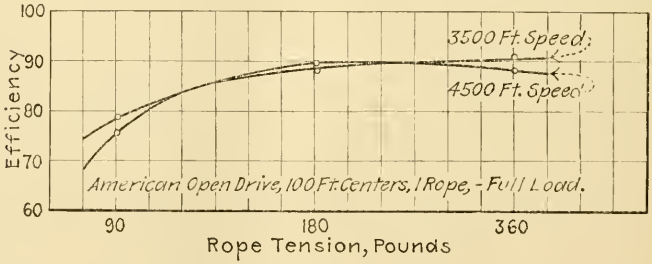

Fig. 11 Curve Showing Efficiency plotted against Various Rope Tensions

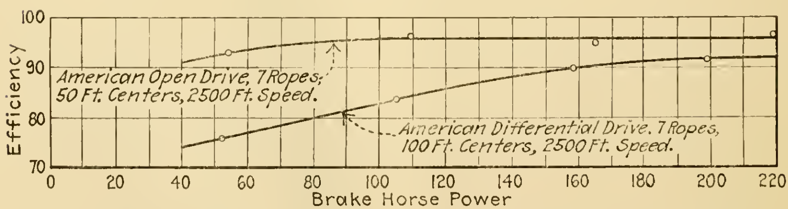

Fig. 12 Curve showing Comparison between Exact and Differential Drives

various loads. Owing to the limited capacity of the motor (250 h.p.) the slippage point was not reached on many of the tests involving the higher speeds and number of ropes. In these cases the high record was taken at the motor capacity and so recorded.

17 In all of the above tests the tension in the slack side of

the rope was kept as uniform as possible at 180 lb. by means of weighting the tension carriage properly. In order to ascertain what tension would give the greatest degree of efficiency, irrespective of life of rope or wearing qualities, a test was made with the slack rope under varying tensions, the results of which are given in Fig. 11. This is shown on one rope because the capacity of the single rope was, under the heavy tension, as great as that of the motor, so no proper comparison could be obtained on more than one rope.

18 One of the greatest troubles in rope driving, when installed by inexperienced engineers, has been the lack of uniformity in pitch of the grooves where many ropes were used. This differential in the grooves compels slippage of the ropes which not only causes loss of power, but also rapidly depreciates the rope, and often causes the rope to flop around badly. To test the loss of efficiency in this case two wheels 60 in. in diameter, of eight grooves each, were made up exactly alike so far as could be, and after most careful measurements the grooves on either wheel were found not to differ more than 1/64 in. in circumference from any other on the same sheave, and a test made. The driver was then removed, and the pitch diameter of each groove made approximately 1/32 in. less than the preceding groove so the eighth groove was ¼ in. less in diameter than the first one. Again it was placed on the driving shaft and a duplicate set of tests made, the general tendencies of which are given in Fig. 12. In this test as the first groove was ¼ in. larger in pitch diameter than the eighth groove, with the sheave revolving at 160 r.p.m., there would necessarily be a slippage in an inelastic band of over ten feet per minute.

19 The photographs taken of this differential drive, shown in Figs. 13 to 16, in which the horsepower transmitted is 52 h.p., 110 h.p., 165 h.p., and 220 h.p., are quite illuminating, as they show plainly the sag of the various ropes under this condition, and how under heavy load they stretch and slip on the grooves of the sheave. The elasticity of the rope in this case undoubtedly lends itself to aid efficient operation.

20 The "up and over" American drive, so called because of its course upward from a driver, over idler wheels, then horizontally for a distance and down over idler wheels to the driven wheel, was tested because it is typical of all but direct drives,

FIG. 13 AMERICAN DIFFERENTIAL DRIVE, 100 FT. ON CENTERS, SIX ROPES, 2500 FT. PER MIN., 55 H.P.

FIG. 14 AMERICAN DIFFERENTIAL DRIVE, 100 FT. ON CENTERS, SIX ROPES, 2500 FT. PER MIN., 110 H.P.

FIG. 15 AMERICAN DIFFERENTIAL DRIVE, 100 FT. ON CENTERS, SIX ROPES, 2500 FT. PER MIN., 165 H.P.

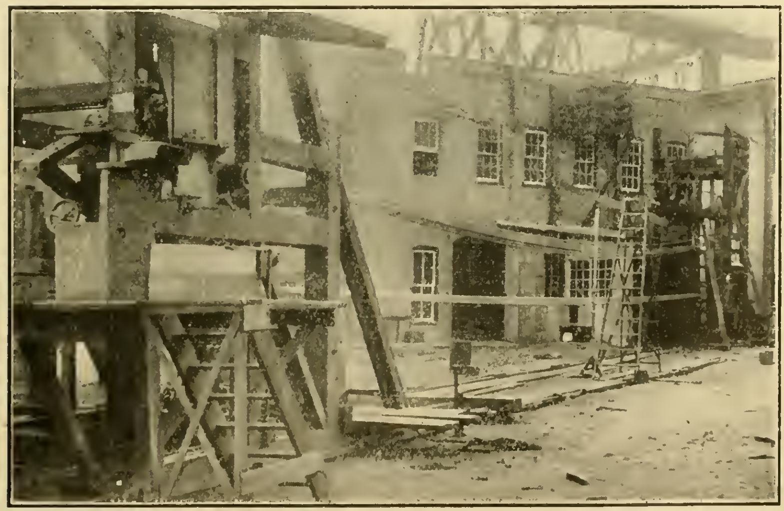

FIG. 16 AMERICAN DIFFERENTIAL DRIVE, 100 FT. ON CENTERS, SIX ROPES, 2500 FT. PER MIN., 220 H.P.

i. e., straight from driver to driven, and the difference in efficiency between this type and the open drive, as shown in Fig. 17, will serve as a basis of comparison where but two additional right-angle turns are introduced requiring four additional idlers. This test was run on approximately 100 ft. centers with a new rope, the same rope being afterwards used in the testing of the various English drives.

21 In testing the English drives, that proper comparisons

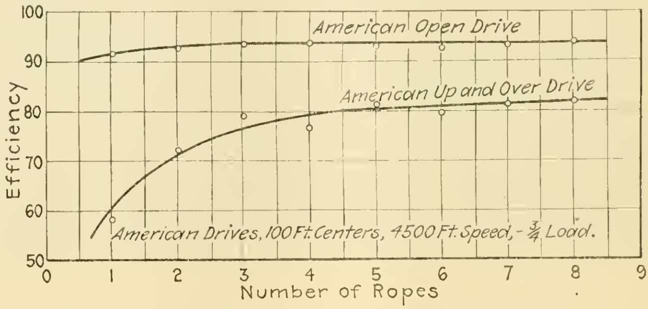

Fig. 17 Curves showing Difference in Efficiency between American Open Drive and American "Up and Over" Drive with varying Numbers of Ropes

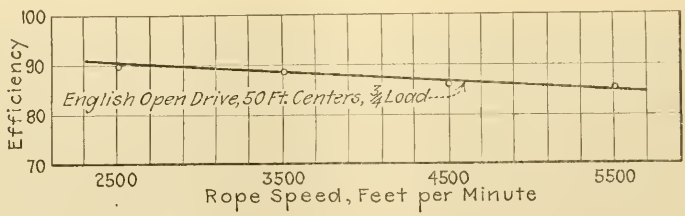

Fig. 18 Curve showing Efficiencies at Different Speeds with English Open Drive

might be made, the ropes were all cut to the same measured length, and the splices carefully made, so that all ropes might be equally tight when applied to the sheaves. The movable tower was then carefully moved back, the rope being run slowly meanwhile until the sag in the rope was approximately the same as in the American drive of the same center distance in which the slack rope was under a tension of 180 lb. This is undoubtedly a higher tension than is used in general practice on the English drive system with this size of rope, and the capacities

and efficiencies shown are perhaps higher than are ordinarily attained in common practice. Fig. 18 gives the efficiencies, when compared by speeds, of the English open drive. This shows a

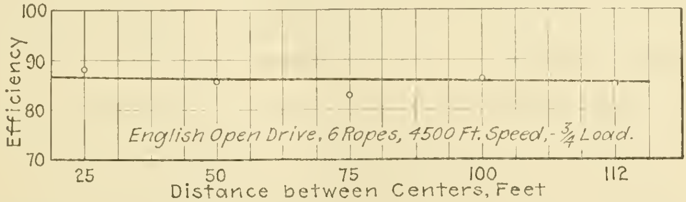

FIG. 19 CURVE SHOWING EFFICIENCIES OF ENGLISH OPEN DRIVE WITH VARYING CENTERS

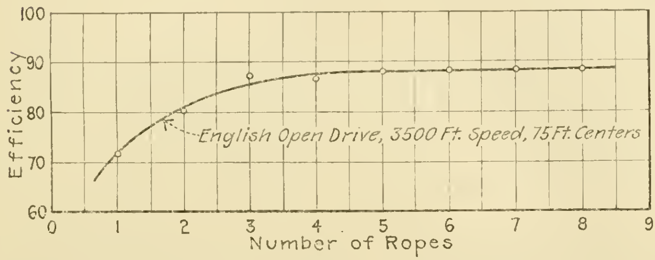

FIG. 20 CURVE SHOWING EFFICIENCY OF ENGLISH OPEN DRIVE RELATIVE TO NUMBER OF ROPES

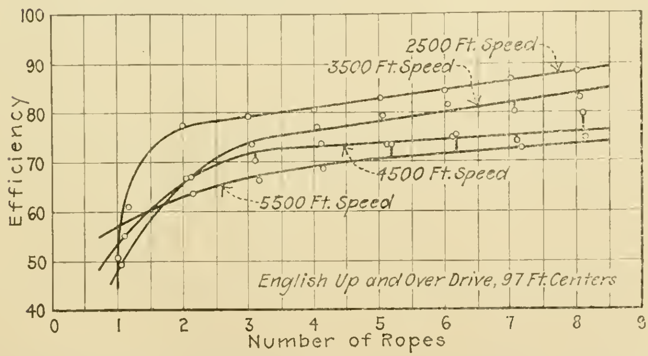

FIG. 21 CURVE SHOWING EFFICIENCIES OF "UP AND OVER" ENGLISH DRIVE WITH DIFFERENT NUMBERS OF ROPES AT FOUR DIFFERENT SPEEDS

marked decrease in efficiency as the speed of the rope increases, falling as low as 84.5 per cent at 5500 ft. rope speed.

22 The general tendency in all tests made, both English and American, was corroborative of this tendency toward decrease

in efficiency as the speed of the rope increases. There was, however, a lack of smoothness to many of the curves owing, it was thought, to variations in rope tension, and perhaps slight changes in the surface of the rope due to climatic changes. This was very much more noticeable on the English than on the American systems, the irregularity of the curve on the former

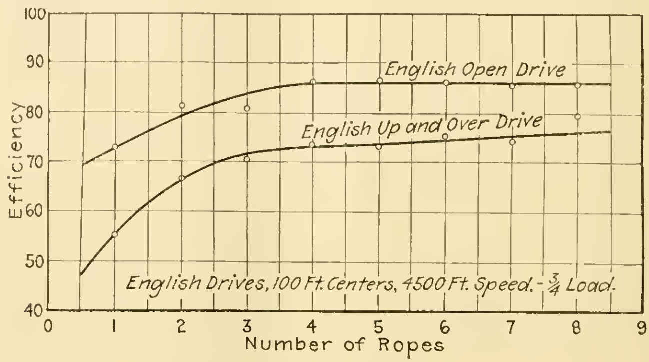

FIG. 22 COMPARISON OF EFFICIENCY BETWEEN ENGLISH OPEN DRIVE AND "UP AND OVER" DRIVE

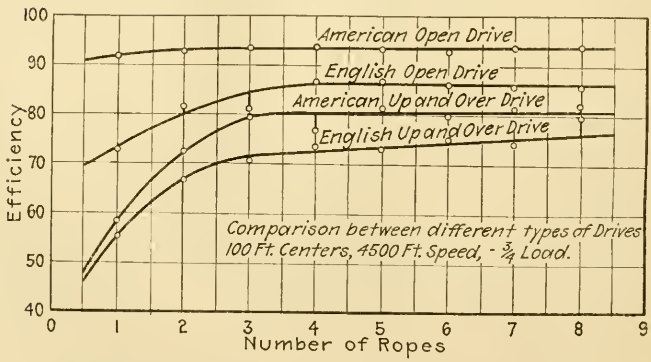

FIG. 23 COMPARISON OF EFFICIENCIES OF FOUR GENERAL PLANS OF ROPE DRIVING UNDER UNIFORM CONDITIONS

being affected by the fact that a greater load was sometimes attained on a certain speed than could later be reached on the next higher speed. The results relative to varying centers with six ropes on the 4500 ft. speed are given in Fig. 19, and Fig. 20 gives the results relative to number of ropes with 75 ft. centers and the 3500 ft. speed.

23 It will be seen by reference to Fig. 19 that the efficiency

of the English drive, within the limit of distances tested, remains practically constant irrespective of center distance; while with reference to number of ropes, it increases as does the American for the first few ropes, and then remains practically constant through the additional ones. Fig. 21 gives the "up and over" English drive relative to number of ropes plotted on the four different speeds. This shows very clearly the greater efficiencies of the slower speeds. The center distance on all the "up and over" drive tests was approximately 100 ft. that direct comparisons with the open drives on the corresponding centers might be made.

24 In order to test the effect of tension on the English system a comparison was made by moving the receiving tower forward 1¼ ft. after making a series of tests, and then making another corresponding series. When sheaves with proper English pinch grooves, as shown in Fig. 6, were used there was no appreciable difference either in power transmitted or in efficiency. Greater variations than 1¼ ft. in center distances could not be satisfactorily tried because of the slack ropes dragging on the ground.

25 A comparison of efficiency between the English open drive and the English "up and over" drive is given in Fig. 22. In Fig. 23 is given a representative comparison of the efficiencies of the four general plans of rope driving on a center distance of 100 ft. and a rope speed of 4500 ft. per min.

26 A new rope was used on the American open drive, another new one being started with the American "up and over," which latter was also used on both the English drives. The time of introducing the new rope is mentioned because it was found that a new rope had very much less capacity, owing to its low coefficient of friction, than the same one had after it had run a short time in work, and having less capacity it would usually have less efficiency also. The stiffness of the rope when it was new also seemed to add friction to the drive owing to the bending action in passing around the sheaves, which on the test were only 60 in. in diameter. With larger main drive wheels, where the rope is not bent to so small a radius, the efficiency would undoubtedly be slightly increased over the results here shown.

27 The capacities of rope drives are affected by so many variables that no particular attempt is here made to state capacity

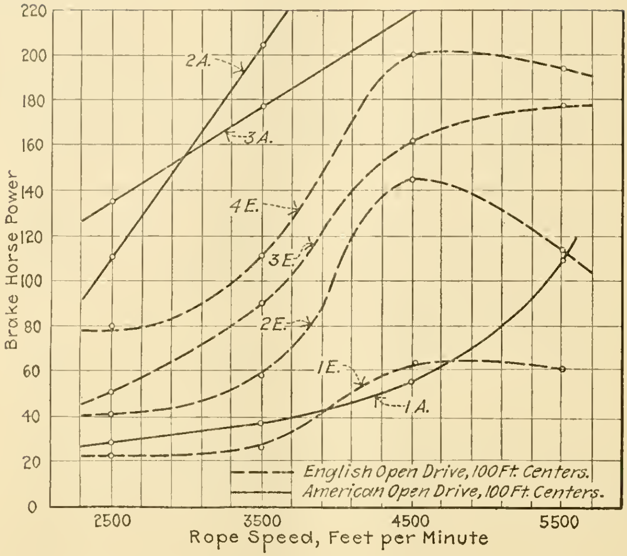

Fig. 24 Curves showing Limits of Capacity of Two Forms of Open Drive at Four Different Speeds

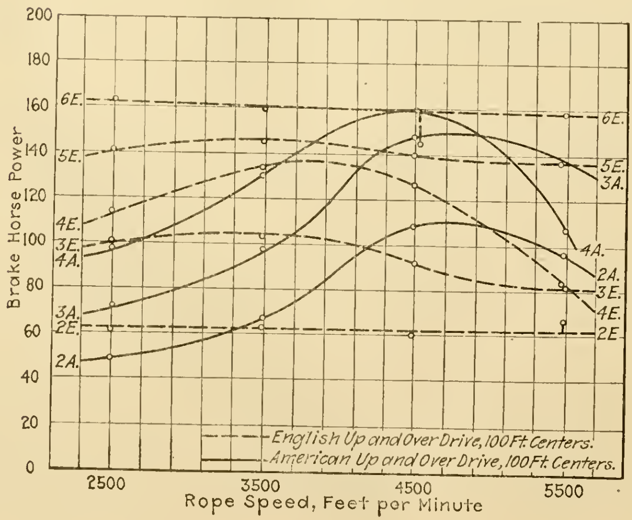

Fig. 25 Curves showing Limits of Capacity of Two Forms of "Up and Over" Drive at Four Different Speeds

other than in general figures, obtained as indicated in the early part of this paper, and used merely to have a uniform method of taking the tests. Fig. 24, however, gives a general idea of some limiting capacities obtained in the open drives, and Fig. 25 some of those obtained in the "up and over" drives. These limiting capacities shown are in no sense to be considered as available working capacities, but merely as limits reached in driving capacities, the general tendency of the whole series being used to form a decision, rather than any one curve, the practical working capacity being much lower than the limits shown. It is to be regretted that the power available was not great enough to get the larger capacities as so few points were obtainable on the American open system. Even at the low speed of 2500 ft. four ropes could not be made to slip with the 250 h.p. available.

28 The irregularities of these limiting horsepower capacities are caused by many variables some of which are weather, surface conditions of rope, condition of rope wheel grooves, etc. In connection with the groove in the wheel it was found that if a rope began to slip in a groove and warmed it up slightly the coefficient of friction seemed to decrease very rapidly, and if a limiting test were made under these conditions it was invariably much lower than if it were taken just before the rope started to slip. As each test had to be taken in its scheduled order some of those shown were taken at intervals of several weeks.

29 As the limiting capacities of the English drive are very much lower than the American, it is thought the efficiency is likewise affected, the friction in the former case being a much larger proportion of the power delivered. And again, the English system in order to get driving power in the rope, pinches it in the narrow groove requiring considerable force again to withdraw it. This effort being exerted many times a minute uses up considerable power. The American system, on the contrary, uses a 60-deg. groove into which the rope lies freely and withdraws without effort.

30 In conclusion, much credit is due Mr. W. H. Tupper who gave important aid in the electrical part of the work, and to Mr. E. M. Carver who personally superintended the test work and carried out the major part of the computations.

THE MYRIAWATT AS A UNIT OF POWER

The proposal of the myriawatt, as a new unit of power to replace the boiler-horsepower, in a paper by H. G. Stott and Haylett O'Neill before the annual convention of the American Institute of Electrical Engineers in June 1912, was referred to in The Journal for February 1913, as well as the Society's special committee on the myriawatt in joint meeting with the Standards Committee of the American Institute of Electrical Engineers on December 23, 1912, favoring its adoption. The action incited discussion from William Kent and George H. Barrus, which was printed in The Journal for May 1913, and in order to bring the question before the Society as a body, an opportunity for further discussion was offered at the Spring Meeting at Baltimore, Md., May 20 to 23, 1913. The discussion offered is presented below, notable among which is a statement by Haylett O'Neill, one of the authors of the original paper proposing the unit.

DISCUSSION

Further discussion was contributed by Geo. H. Barrus, vice-chairman of the Committee on Power Tests, in the form of extracts from letters received by him from members of his committee, as follows:

E. F. Miller says

I can see absolutely no reason why we should adopt the myriawatt. I think it would be a mistake for our committee to recommend that this unit be used.

L. P. Breckenridge says

It would seem to me unfortunate if we should adopt a myriawatt which would do away with our old friend the horsepower. I am in accord with your presentation.

Arthur West says

I am decidedly opposed to the exclusive use of myriawatt as a measure of boiler capacity, for the reason that boilers are not employed exclusively as a means for producing electricity. When boilers are used for other purposes, an entirely unnecessary and perhaps confusing complication is introduced.

Carl Schwartz. Mr. Kent has made it quite clear that he disapproves of the report of the committee. In The Journal

for May he states, "The gallon, a useless unit, is slowly being replaced by the cubic foot, etc." We also find, "The horsepower is here to stay and we can no more eliminate it than we can eliminate the gallon, etc." The discovery of a method is announced of bringing both electrical and thermal units into a simple relation with the English system, so Mr. Kent must have felt that there is a clear demand for just such a thing as the myriawatt, still he does not hesitate to propose a method he thinks has undeniable merits but which it is seen at a glance can hardly be made more complicated.

Mr. Kent objects to the introduction of the new term myriawatt which, in fact, is an old unit with a new self-explanatory term and a new application, but recommends a "vim" system for which he advocates not less than six new terms as follows: vim, kilovim, volt-vamp, therm, vamp and vohm. In addition to this, the centigrade thermometer scale is stated to be defective in having its zero point at the freezing point of water and this serious disadvantage is proposed to be eliminated by a new thermometer scale. Also, the ammeter is not satisfactory for this system and a new graduation is proposed for converting the ammeter into a vampmeter. An instrument for alternating-current measurements is not given. All of the above suggestions are made in the face of the statement that the average man cannot think in a great variety of units.

Mr. Kent also refers to a recent attack on the English system by the Bureau of Standards, to destroy the old definition of a horsepower as 550 ft-lb. per sec. and define it as 746 watts. The horsepower has long been equal to 746 watts and if the old definition of 550 ft-lb. per sec., or 33,000 ft-lb. per min., was eliminated it would reduce the great variety of units against which such strong objection is raised. The myriawatt, however, is more convenient than the watt or kilowatt because it can be reserved for power input measurements.

The earlier mechanical engineers can agree to eliminate the English system for scientific measurements and substitute a system of units based upon standards in use on the European continent and by electrical engineers, the better it will be because it has long been unfortunate that results of tests and calculations made on the basis of different systems are exceedingly difficult to compare.

Mr. Barrus states that the myriawatt is not a new unit and

that it is already international, but asks why the watt or kilowatt should not be used instead. The use of the watt or kilowatt instead of horsepower would be a distinct advantage, still the use of a term strictly applicable to input measurements seems more desirable.

Mr. Barrus' principal objection is apparently sentimental and seems to rest in an opposition to electrical engineers because he states that the output of a steam plant is 12 per cent and he does not want the tail end to control power plants in general. It would be well for Mr. Barrus not to forget that the "tail end" has an efficiency of between 97 and 95 per cent as compared with say 15 per cent of the head end and that the development of the electrical part has been materially assisted by highly efficient methods of measurement and calculation.

It is hoped that a full discussion of the subject will place before the membership clearly all reasons for the use of the myriawatt instead of the boiler-horsepower and similar units like the "evaporation of one pound of water evaporated into dry steam from and at 212 deg. per hour."

The use of the myriawatt, a unit based on the C. G. S. system, will give us one distinct system of units for all parts of the power plant from the coal pile to the bus bars and make all calculations understood internationally. For scientific calculations, the English system is obsolete today and is discarded by scientists, chemists and electrical engineers, and it should be borne in mind that this matter has no bearing on the question of the relative merits and demerits of the metric system as a unit of practical measurement in manufacture.

Henry Hess. A great deal has been written and a great deal has been said which is altogether foreign to the question at issue. About everything that has been said for and against the myriawatt applies with equal force for and against the watt. The watt is, however, not a unit that requires any defense. It has been in existence, adopted and used for many years. The myriawatt is nothing but a convenient collective noun; it means simply so many watts. The myriawatt is a matter of convenience; absolutely no matters of boiler-horsepower, etc., have anything to do with the question. The whole matter boils down to the one simple thing, do you wish to use a single unit which is a multiple of one already in general use and acknowledged by the objectors

to the myriawatt, or do you prefer to continue to express yourself in the smaller unit watt and its present multiple, the kilowatt? I went to Germany a number of years ago to build a plant there and I took with me a great many drawings of machine tools, which were there redimensioned in the metrical system. I happened to have a problem one day that involved one of our American units and turned the calculation over to a draftsman. This problem involved length, area and volume. The result turned in did not work right and was turned back with instructions to let five men calculate independently. All five agreed as to the figures, but only two agreed as to the location of the decimal point. I insisted on the use of American units without any conversion to the metrical system. I obtained four alike and correct, and one wrong, but with wrong figures. The men were simply confused through the large number of ciphers. Reasoning from that experience, anything whatsoever which cuts down the number of ciphers by using larger units will result in clarification and greater certainty through easier mental conception.

Richard H. Rice. At present in testing steam turbines we use on the electrical end certain instruments based on the C. G. S. system, and on the steam end we use an entirely different set based on the fahrenheit-pound-second system. If we adopt the myriawatt we can use instruments on both ends of the apparatus based on the same system, which seems very desirable.

O. P. Hood. The acceptance of the myriawatt is but a part of the main question, are the mechanical engineers ready at this time to step over to the C. G. S. system?

To begin such a change by accepting a substitute for the boiler-horsepower would seem to me a mistake. We ought to face the general problem and step over bodily with all our units or leave the matter alone.

Charles E. Lucke. I am decidedly opposed to the exclusive use of myriawatt as a measure of boiler capacity for the reason that boilers are not used exclusively as a means of producing power for electricity, and further because more confusion than gain will result from such a change.

Haylett O'Neill.[1] The authors are greatly indebted to

[1] Assistant Engineer Interborough Rapid Transit Co., New York.

Messrs. Kent and Barrus for their discussion of the unit, myriawatt, but an analysis of their arguments reveals the fact that neither of them comprehends the real intentions of the authors in proposing this unit.

Mr. Kent attacks it because it is new, while Mr. Barrus protests that it is not a new unit. If Mr. Kent objects to a single new unit, or rather to the substitution of a rational for an irrational unit, why does he thrust upon engineers a whole system of new and complicated terms?

Objection is made to the kilowatt, or its multiple, on the ground that it is not derived from fundamental units, as is the horsepower. Superficially, this would seem like a real argument especially when we think of belted generators, and all kinds of mechanical transmission in vogue before the advent of the electric generator and motor. But in these days, the call is for direct-connected prime-movers and auxiliaries.

The best steam-engine indicator gives only an approximation of the power delivered by an engine, while there is nothing to take its place on the steam turbine. Even the brake method of power determination is usually inaccurate, and is 100 per cent wasteful. On the other hand, with the electrical method of testing, all the energy developed may usually be utilized, and the most accurate possible determinations are made. With most direct-connected units, it is impossible to separate the mechanical from the electrical power, and with machines where this can be done, the best way of testing in practically every case is the electrical method. Thus for a long time to the majority of engineers a unit founded on the watt appeared to possess remarkable advantages over the horsepower as a unit for power measurement. Besides, the watt or kilowatt is used everywhere. There is only one kilowatt and every engineer in the universe knows what the word means. But when one mentions the word horsepower, who knows whether he means boiler-horsepower, indicated-horsepower, brake-horsepower, heater-horsepower, economizer-horsepower, electrical-horsepower, or continental-horsepower?

It is stated that mechanical engineers think in horsepower and find the term in all their reference books; but this is true only of English speaking people, and English and American reference books. Even though Mr. Barrus avers that the con-

version of units from one system to that of a foreign country involves only easy mental arithmetic, it is a sure gamble that to do so, most engineers would have to consume an abnormally large quantity of mental energy. When we have an international unit in use which could be universally applied every day, why do we still burden ourselves with a term of only local use and meaning?

The myriawatt was proposed principally for three ends:

a To substitute a unit founded on the C. G. S. system for a local unit, the boiler-horsepower, without effecting any radical changes in rating of energy converters.

b To supply a term which would connote power quantities on the input side of prime-movers, based on the same system as that of the accepted unit of output.

c To form a wedge for driving home the metric system of measurements.

Nearly all admit that the term boiler-horsepower is bad. Some suggest that the kilowatt might serve the same purpose as the myriawatt. This would almost be admitted were it not for the fact that the term kilowatt as used in connection with a power plant has become almost inseparable from the output. Besides it requires no real effort to think of a 600 boiler-horsepower boiler as a 600 myriawatt boiler, while it requires much imagination of the average man to rerate a 600-horsepower boiler as a 6000-kilowatt boiler. The myriawatt will in time connote the power on the input side of prime-movers, just as the kilowatt now universally suggests output.

Although in the paper on the myriawatt all terms were reduced to B.t.u., this was done only for the convenience of users of the local British system, the ultimate aim of the authors being to open the door to the universal use of the metric system. The fact that the British thermal system is tied to the factor "32 deg. above 0 deg" is enough to condemn it as complex. Who is there who has not at one time or another omitted or inserted the factor 32 in the wrong place with sad results?

Objection is made to the prefix "myria" that it does not convey a definite quantitative meaning. But if every grammar school graduate has been taught the relationship of the "myria gram" to the "gram," and of the myria meter" to the "meter," would it not be surprising if the engineer with all his training could not apply the easy analogy to the "watt"?

Were it not for the inevitable confusion in terms, it might be as well to rerate the boiler-horsepower as being equal to 34,150 B.t.u. per hour instead of 33,479 B.t.u. per hour. The prefix "myria" was thought to convey most clearly the relative quantity meant, while the "watt," named after the pioneer practical boiler-room engineer, will bring the mechanical department into harmony with the universal system of measurements.

The only real argument against the myriawatt is its newness. But its great benefit will be the linking of the mechanical with the electrical, and the internationalizing of our electrical and mechanical units.

H. G. Stott. Messrs. Kent and Barrus have criticized this recommendation very severely, and in doing so they have advertised the proposed change a great deal better than I could have done. The object of the myriawatt is to do away with the anomalous position which we now have in regard to the use of the term horsepower. If I should put the question, what is horsepower, to a body of engineers there would probably be at least five different answers. The man interested in economizers would tell me one thing as to horsepower; the man interested in boilers would tell me in square feet; the man interested in reciprocating engines would tell me it is the indicated horsepower; the man interested in other apparatus might speak of brake-horsepower, while the man interested in steam turbines would say "I don't know because there is no way of measuring it." The units have become so large they are almost invariably coupled to centrifugal pumps, blowing apparatus or electric generators. There is no way to separate the electrical or power output of the unit and the input, so that horsepower has ceased to have any meaning so far as the large producer of prime-movers is concerned. The steam turbine today is the type of unit which is being adopted for all purposes, marine, through gears, electrical generation, and for almost every purpose, because it seems to be much simpler and also because it involves a much lower initial cost.

Mr. Kent says that the mechanical engineer thinks in horsepower. Just what is horsepower? I have tried to find out, and there are at least half a dozen different kinds. I don't know which one you mean, when you say horsepower.

He also refers, I think through a mistake, to the definition of

the myriawatt, which is the same thing as saying that the myriawatt is 10,000 times the watt. It is not an electrical unit, but a dynamical unit. It is a non-gravitational unit and therefore independent of the weights or position on the earth in which the measurement is taken. It is equal to the acceleration produced by force equal to one erg upon a mass of one gram having a uniform velocity of one centimeter per second. There is absolutely nothing electrical about that, so that the evident objection which both Mr. Kent and Mr. Barrus make, that we are trying to introduce an electrical unit into mechanical engineering, is wiped out because the fundamental definition of today is ten to the power of seven C. G. S. dynamical unit.

This system has been adopted officially by 22 governments, that is, practically every civilized government of the world has adopted the C. G. S. system officially and it is legalized in all those 22 countries. In comparing the results obtained, for example, by a power station having turbines with those obtained in Europe, it has been my misfortune at various times to have to turn kilograms and calories into B.t.u. and finally to resolve the whole thing into pounds of steam per kilowatt-hour. We cannot say per horsepower, and we are practically forced to use the kilowatt or some multiple of the watt as a unit of power. It is a very happy thing because it will advance the internationalization of our system of units and make them comparable with the results obtained in Europe.

A number of other objections have been raised: Mr. Kent says the authors have taken up this old and discredited unit. I take issue immediately with the author of this article by saying that the boiler-horsepower is not an old and discredited unit. I wonder how many boiler tests are worked out today without referring to it. I personally have never seen any. It may be discredited in his mind but it is not discredited in practice. It so happens that the myriawatt, which is simply 10,000 watts, is almost exactly equal to a boiler-horsepower, there being just 2 per cent difference, and this nominal change would have no influence upon actual practice. The rating of boilers as to whether it is 2 per cent plus or minus is negligible for we all know a boiler is not driven at rated horsepower. We then have to consider the method of comparing it directly with the output on the switchboard or in whatever shape it may be, as the watt being a dynamical unit can be considered. Another considera-

tion was that the average thermal efficiency of the ordinary plant today is about 10 per cent, that is to say, take the thermal input in units of ten and you usually come out with about one at your switchboard, so that one myriawatt input in the boiler would represent about one kilowatt on the switchboard, some plants doing as well as 12 or possibly 13 or 14 per cent efficiency.

Mr. Kent gives a definition of the gram as one which involves the question of gravity. I particularly pointed out that mass has absolutely nothing to do with gravity: it is a non-gravitational unit. The criticism, therefore, does not apply. Mr. Kent, by objecting to the introduction of a new unit and recommending six new units, has himself very effectually answered his own criticisms.

Mr. Barrus criticizes the use of a new unit of power and afterwards corrects himself by saying it is simply a new multiple. He refers particularly to the British thermal unit as the only absolute standard countenanced. That is not so. I believe the next step will be the introduction of the centigrade thermometer scale. We are all familiar with the difficulties, especially the younger men, which have been encountered in the use of the 32-deg. freezing point. There is always a plus or minus position there which might lead to errors in calculation; and by having the freezing point zero, instead of 32, we avoid that. The centimeter gram second system is in use today in the United States. Every chemist uses it. When we send in a sample of coal to him for analysis, he uses grams and brings out the results in calories and then converts back to B.t.u. All that could be avoided by the introduction of the centigrade scale, which is today exclusively used in electrical measurements, in chemical and electro-chemical and metallurgical work, so that it is no great step to introduce the centigrade schedule into steam boiler or thermo-dynamic calculations.

What would Mr. Barrus measure the power of a turbine of 25,000 or 30,000-kw. capacity? Would he put a brake on it? He cannot separate the mechanical and electrical; he must measure the electrical output. All garantees of the turbine unit are given in terms of the output on that unit because there is no other way of measuring it without wasting an enormous amount of power. This, therefore, is another reason for adopting the proposed change.

THE PRESENT CONDITION OF THE PATENT LAW

INCLUDING RECENT AND PENDING DECISIONS OF THE SUPREME COURT OF THE UNITED STATES AND PROPOSED PATENT LEGISLATION

By Edwin J. Prindle, Published in The Journal for April

ABSTRACT OF PAPER

The decision of the Supreme Court in the Mimeograph case, sustaining the right of the patentee to require the purchaser of the machine to buy of the patentee ink and paper for use on it, has resulted in the introduction of a large number of bills in Congress, with a view to cutting down the patentee's monopoly. This paper explains the Mimeograph decision and, incidentally, the general nature of a patent and the monopoly which it grants, and explains the Bath Tub case recently decided by the Supreme Court; the price-restriction case of Bauer vs. O'Donnell, now before that Court for decision; the relation of the patent law to the Sherman act; and the general nature of the proposed legislation and its effect on the patent law, and upon manufacturers and inventors.

DISCUSSION

J. Nota McGill.[1] Mr. Prindle's paper should awaken the members of the Society to a realization of the necessity for vigorous protest against the enactment of dangerous legislation aimed at the fundamentals of our patent system, and which, if enacted, will be a fatal step backward and tend seriously to impair that set of laws which has done more for mankind physically, socially and financially, than any laws on our statute books.

The growth of that system has been co-extensive with the growth of our country; it can truthfully be asserted that to the growth of the inventive genius of our people is due America's great progress. The increase in population in practically the last 60 years of the 19th century was about 530 per cent; the increase in patents about 6400 per cent. At the beginning of the 19th century the world knew nothing of telegraphy, telephony,

[1] Secretary, Patent, Trademark and Copyright Section, American Bar Association, Washington, D. C.

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steam navigation, or the myriads of labor-saving devices, the introduction of which has revolutionized the social, financial and commercial world. At that time agricultural products constituted our export trade. Manufactured products were nearly all imported, as it had been England's policy to suppress all industries of this kind in the colonies.

The American inventor could, with justification, claim much at the hands of his country; he asks only for fair treatment. In the grant of patents for inventions there is no undue advantage bestowed upon any man; the inventor is given the right, for a limited time, to *exclude* others from practising his invention, on the condition and with the express understanding that he shall disclose and make known to the world what he has produced, so that at the expiration of that limited period the public may be free to use his invention without payment of tribute.

Until a few short months ago no serious complaint was heard against our patent system. Then suddenly came the proposed amendments. If we look for a cause it is difficult to find, unless it be the methods adopted by the Shoe Machinery Trust. But even granting that their methods were the cause, it is a safe assumption that had there been no dissenting opinion in the Dick case we would not today be confronted with menacing legislation. There has been no public clamor for a change. The pronouncement in the Dick case involved no new proposition of law. The decision in the Button Fastener case was rendered in 1896, and for 16 years thereafter (nearly the lifetime of a patent) the commercial world accepted the doctrine of that case practically without question, and the public suffered no hardships. The public are not required to take what the patentee offers if his terms are unreasonable. If they subscribe to the conditions imposed it is but a tribute to the value of the invention. If, on the other hand, they are not accepted, the public are deprived of nothing to which they had any legal or moral right. The patentee is alone the sufferer if in consequence of his attitude he is without a market, and this fact alone precludes him from ever imposing unreasonable demands. The American public can be depended upon neither to require nor to accept unfair conditions in affairs of business.

The other radical change now advocated (compulsory licenses) is even more dangerous and less justifiable than the curtailment of the right to dictate the terms of use and sale.

It has been said that the patent privilege "encourages the inventor to bring his invention to the highest possible condition of practical utility by inventing improvements on it constantly, in order to keep pace with the public wants and to control the trade from which his compensation is derived." But this stimulus to improve will no longer exist if the patentee is to be penalized because of the improvement.

Mr. Edison stated to the committee of the House that while he had heard and read numerous statements that many corporations buy valuable inventions to suppress them, he did not know of a single specific case of suppression. When Mr. Fish asked the committee if during the hearings or at any time there had been brought to the attention of the committee a single specific case of suppression, he was told that *one man* had stated instances where his own inventions had been suppressed. Considering the fact that over a million patents have been granted in this country, the complaint of a single or even a hundred or more persons is practically negligible.

It is unreasonable to assume that the American manufacturer would for a moment refrain from placing on the market an invention that would insure a fair return on the investment. American capital has never been known to indulge in such pastime as is suggested by a handful of persons demanding privileges which the law has always reserved to the inventor and those claiming under him.

Once suffer such an amendment to be made, and a serious blow will be struck the inventors of our country. Capital, ever apprehensive, will hesitate to accept the risk entailed; the inventor will find it more difficult to secure support; and progress will be arrested if the cost of adopting an improvement may mean an advantage to competitors, royalty or no royalty.

Action and untiring action alone will avert the impending dangers pointed out by Mr. Prindle. Concede to the members of the committee of the House the best motives, they are not actuated by any desire other than to discharge their duties honestly and faithfully. It is within the power of the members of this Society interested in maintaining the integrity of our patent system to impress upon every member of Congress that the proposed changes are not desirable, but on the contrary will prove a decided menace.

The author did not desire to present a closure.—Editor.

COST OF UPKEEP OF HORSE-DRAWN VEHICLES AGAINST ELECTRIC VEHICLES

By W. R. Metz, Published in The Journal for April

ABSTRACT OF PAPER

A great deal has been written on the subject of motor trucks versus horse-drawn vehicles, but it appears to be extremely difficult to obtain exact figures, as most firms regard the item of hauling as an overhead expense not worthy of the minute examination given to the other departments.

The motor-driven vehicle is unquestionably cheaper to operate than is the horse-drawn vehicle where a number of vehicles are used, and, in the opinion of the writer, the only question to be determined is the advisability of using electric or gasolene-driven machines. From figures on hand, it appears that the cost of upkeep of the gasolene-driven machines is about double per mile that of the electric-driven machines (not including driver's or helper's wages), but, on the other hand, the gasolene-driven machines have a much larger radius of operation and, in certain cases, this would more than offset the cheaper upkeep expense of the electric-driven machine.

As a general proposition, it appears that the electric-driven machine is better for city service where the streets are in fairly good condition, and that the gasolene-driven machine is better for long hauls over rough roads and in the open country, mainly on account of the ability to obtain gasolene and water, and the chances of making greater speed.

DISCUSSION

H. H. Smith.[1] Scientific cost keeping is unfortunately a very modern practice, and we who must displace outworn institutions with new and better ones are at a disadvantage because there is nothing tangible available concerning the old.

The saving effected by the substitution of power trucks in the case cited by Mr. Metz is surprising, as it is not unusual for the cost of operation during the first year to be reduced very little. Usually this is because the delivery routes and system have not been altered where necessary to fit the new conditions. Obviously if an electric truck is given the work of a horse truck on

[1] Edison Storage Battery Co., Orange, N. J.

The American Society of Mechanical Engieers, 29 West 39th Street, New York. All discussion is subject to revision.

the horse-truck schedule, the cost per delivery will be much higher because the advantages of the motor-driven vehicle will not have been properly utilized. The case under discussion indicates what may be accomplished by careful study and rearrangement.

Another point brought out in the paper which confirms other investigations along the same lines is the insignificance of the cost of energy in the operation of electric vehicles. It seems to run generally between 6 and 10 per cent of the total cost. Repairs and depreciation usually constitute a greater item of expense, while the cost of labor ranges from 40 or 50 per cent up. These relations should be carefully borne in mind when the purchase of trucks is under consideration.

It is an interesting fact, brought out more clearly in other investigations, that the advantage of the electric wagon over the horse wagon increases with the distance of the delivery zone from the starting point in light parcel delivery, and with the weight of the load in work near the point of distribution. It is even recorded that the horse may be of slightly less cost in congested territory where the radius of action is small and the number of stops large.

It is stated in the abstract of the paper that possibly the gasolene truck meets with favor in certain classes of service because of the ease with which fuel may be obtained. This may be true today, but it will be a matter of only a very short time when power companies will have boosting stations in as large numbers as could be desired and there will also be garages with boosting facilities when the demand is present. If careful study is given to the transportation problem, however, boosting will not be required in commercial service except where it has been specifically allowed for in the design of the vehicle.

A. M. Pearson.[1] The principal feature which Mr. Metz's paper indicates is the fact that the horse is a thing of the past. It does not take a long stretch of imagination to see why this is so when you take into consideration that the volume of business of this country has increased about 165 per cent in the last ten years, and that the number of horses and mules has only increased about 10 per cent; therefore, the only means by which this increased business, which means increased distance, as well as increased

[1] The Locomobile Company of America, 2314 Market St., Philadelphia, Pa.

volume could be overcome, was to substitute a mechanical method of transportation for a physical method. But there are still many serious problems facing truck manufacturers and truck distributors, the largest one of which is the one called the customers' problem; that is, methods by which the short haul and the facilitating of loading and unloading of merchandise, and the increase of the efficiency of a single unit in the form of a truck may be accomplished.

There are still many things to be desired. For instance, the company that I represent makes a truck with an engine which has a capacity of 45 h.p. It is obvious that there should never be a state of affairs where a truck with such an engine would stand idle while six or eight men load it. The power of this engine should be utilized in every instance for loading and unloading, and all the concomitant features of transportation to bring into existence the full efficiency of a motor vehicle.

We know how to build a chassis; we know how to build engines, both electric and gasolene; but there are many other things which are directly in line with the craft which this Society represents that are badly needed and clearly indicated. For instance, we need folding boxes, and we need them very badly. There have been many folding boxes placed on the market, but there seems to be some weakness in the hinges, which prevents the article from being a practical part of transportation.

We need different types of dumping bodies from those that are now offered to the public by body makers. Too many people are trying merely to place a truck instead of so many horses, and too many body builders are offering us the same conditions as we had with horse wagons. What we need are bodies that are made and adapted especially for motor vehicles. We need different power appliance; we need a satisfactory winch for a truck; we need a satisfactory crane for a truck, and in all these appliances we need a condition whereby the number of men necessary to operate them is reduced to the minimum.

L. H. Flanders.[1] The general agreement in results and conclusions of the paper with the reports of the electrical engineering department of the Massachusetts Institute of Technology in its exhaustive investigations of The Economical Transportation of Merchandise in Metropolitan Districts, is observed.

[1] The Electric Storage Battery Co., Philadelphia, Pa.

In the last report, Vehicle Research Bulletin No. 3, presented last March before the Electric Vehicle Association, Messrs. Pender and Thompson show how important is the study of service requirements, in securing a proper selection of the size and type of vehicle to give a resultant minimum cost. Among the figures they present the time the wheels are in motion to the time the vehicle is in service, i.e., the mileage factor, is most impressive.

Referring to Mr. Metz's paper, Table 13, the average mileage per day runs from 20 to 24 for the electrical vehicles at a cost of from 33.8 to 36.1 cents per mile, of which roughly two-thirds is labor for drivers and helpers, while with the horse-drawn vehicle the driver and helper wages amount to about 44 per cent of the cost per mile. Anything therefore that will increase the percentage of the time the wheels are turning will decrease the cost of operation per mile.

It would also appear that with a mileage factor such as would necessarily exist it would often be foolish to run even a 2000 lb. capacity vehicle continuously at the speed that now prevails. With a reduction of speed, vehicle and battery maintenance drop an amount well worth the sacrifice. To illustrate: Assume from Table 13 that the 2000-lb. electric truck is in service 10 hours. It has a maximum speed on the level somewhere near 12 miles per hour, and an average speed of say 8 miles per hour, which would mean for 20 miles per day an actual running time of 2½ hours, with an idle time of 7½ hours. By cutting the maximum speed to 9 miles per hour the time of running would be increased to only 3 hours, which would necessitate a reduction of half an hour in the idle time, or approximately 7 per cent. This is particularly true in congested city streets where it is impossible to utilize the high speed on account of frequent stopping and starting.

Effecting this change through increased gear ratio would mean reduced battery draw for a given tractive effort or a greater tractive effort for hills and greatly reduced vehicle and tire depreciation. To the very fact that the electric vehicle is a so-called slow-speed machine may be attributed one of the reasons for its superior economy in nearly every situation over the commercial gasolene vehicle. The larger the scale upon which the electric vehicle is used the greater is the economy, particularly in battery efficiency and maintenance.

The radius of operation with electric vehicles has been much increased in the last few years by coöperation between the vehicle

manufacturer, the motor manufacturer and the battery manufacturer, each designing his part to make a harmonious equipment suited to the particular service.

Attention is called in the abstract of the paper to the larger radius of action of the gasolene machine as well as to its greater cost of operation as compared with the electric car. In this connection there would appear to be many an opportunity for increasing the radius of action of the electric vehicle by changing batteries or boosting during periods of idleness at outlying distribution points, or at the home loading platform during the noon hour.

In many delivery systems it is the practice to carry merchandise to outlying substations in large gasolene transfer trucks and from the substation to the points of ultimate destination in electric delivery wagons. In collection service the process is reversed. Many of these substations readily lend themselves to taking care of large electric transfer trucks by allowing for changing batteries which will take from 20 to 30 minutes, or by providing facilities for boosting charges. By changing batteries the radius of action of such trucks is, of course, doubled.

The lead storage battery, particularly with that form of construction using protected cores, is adapted to be recharged at exceedingly high rates and with remarkable efficiency for short periods. To be specific, that form may be recharged at an energy efficiency of over 84 per cent and a current efficiency of upwards of 97 per cent. The battery may be recharged at a rate in amperes equivalent to its state of discharge in ampere-hours. This would, of course, mean a decreasing rate of charge. This can be secured practically by providing a constant potential circuit of approximately 2.3 volts per cell, and simply by plugging in the battery without intervening resistance. By this method of charge with 100 per cent of the battery discharged 23 per cent can be restored in 20 minutes; 32½ per cent can be restored in 30 minutes; 52½ per cent can be restored in 1 hour.

With the battery three-quarters discharged 44 per cent of the total capacity can be restored in one hour, giving a total capacity of 144 per cent of the normal capacity on one charge and a corresponding increase of mileage per charge.

Where constant potential circuits of suitable voltage are not available, the battery may be boosted at a constant current, provided gassing (which means wasted energy), and high tempera-

tures are not produced. A safe rule within this limit is to charge at a current rate in amperes equal to the discharge state of the battery in ampere hours divided by the time in hours available for charging, plus one. To illustrate: The ampere-hour meter shows 100 ampere-hours have been discharged from the battery; one hour is available for boosting; the charging rate will be $\frac{100}{1+1} = 50$ amperes for one hour. If 15 minutes are available for charging the rate would be $\frac{100}{1+0.25} = 80$ amperes and the input would therefore be 20 ampere-hours.

Referring to Table 11, this figure would mean on the basis of 3.69 ampere-hours consumption per mile with 95 per cent current efficiency, about 13 miles increased action with one hour available for boosting.

An ampere-hour meter would be necessary as a guide in following this method, and in general the results would be as follows: A vehicle after having given 40 miles on a charge could be boosted so as to give additional mileage as follows: in 20 minutes, 10 miles; 40 minutes, 16 miles additional; 60 minutes, 20 miles additional; 80 minutes, 22.8 miles additional.

The same vehicle could be boosted for one hour after having given 10, 20 and 30 miles from a fully charged battery so as to give 5, 10 and 15 miles respectively.

These data show the possibility for long hauls and the flexibility of application of the electric vehicle.

William P. Kennedy.[1] There is general demand for operation cost information such as is given by Mr. Metz. There has been considerable difficulty in getting accurate cost information from users of motor vehicles, particularly for the reason which is illustrated in this paper, that the installations are made partially instead of completely, and with the partial installation retaining part of the former horse installation, it is hard to segregate cost to do justice to the motor vehicle. Mr. Metz's paper has taken care of this very nicely and shown differences in cost as to partial, initial and final installation. The best practice would be completely to analyze the situation first and prepare a statement of the operating costs, and to use that as a standard

[1] Consulting Engineer, 1790 Broadway, New York.

table, so to speak, by which the entire proposition might be worked out. It is not just nor desirable to make comparison of unit costs of large motor equipment as against the cost of the horse-drawn vehicle in the horse-equipment installation; the only way to arrive at cost in either horse installation or motor installation is to take the entire cost of operation, preferably on an annual basis and, with all the charges against the installation, determine the operating unit cost.

John Younger.[1] In the abstract of the paper there is a statement rather damaging to the gasolene truck, and not at all substantiated by the figures given. Many like statements are made by those favoring the electric storage battery truck, but when the test of actual accounting is applied, they are found to be without actual foundation in fact.

The only gasolene cars mentioned in Par. 8 are Cadillac, Brush, Buick, Ford, Franklin and Maxwell cars. These are distinctly not commercial vehicles, as properly understood, but merely touring cars, probably specially adapted. These cars run at high speed and it is a well-known fact that it is exceedingly difficult to keep the drivers from abusing them by stolen "joy rides" and by fast driving over bad roads. For these and many other reasons, their cost of operation is on the high side, but should not be as high as stated in Table 5 if there had been careful supervision. For instance, the running sheet of a gasolene 5-ton truck selected at random shows that it ran at a cost per mile of \$0.267, i.e., exactly twice the cost of running the so-called gasolene commercial car in Mr. Metz's paper.

It may be interesting to state here the method used by the Pierce-Arrow Motor Car Company in taking operating costs of their 5-ton truck. It will be noticed that every item of importance in determining a true and accurate cost is taken into account, including insurance and garage charges, and a reasonable interest at 6 per cent per annum on the investment. Mr. Metz's figure of 2 per cent on Table 12 is altogether too low, though, of course, in agreement with that allowed on his horse-drawn vehicles.

Investment of truck with full equipment, including body and all tools..\$4800.00

[1] Mechanical Engineer, Truck Department, The Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Interest at 6 per cent per annum	$288.00
General insurance	200.00
Garage at $30 per month	360.00
Driver at $21 per week	1092.00
Fixed charges per year	$1940.00
Fixed charges per day (1/365)	5.32

RUNNING COSTS PER MILE

Tires (8000 miles guaranteed) at $468[1]	$0.05850
Gasolene, $4\frac{1}{2}$ mi. per gal. at 18 cents per gal	0.04000
Lubrication	
Motor, 250 mi. per gal. at 60 cents per gal	0.00240
Transmission, 5000 mi. per 5 gal. at 65 cents	0.00065
Rear Axle, 5000 mi. per 5 gal. at 65 cents	0.00065
Allowance for daily repairs and overhaul (maintained and overhauled at 15,000 miles)	0.02500
Depreciation at 150,000 miles, or seven years	0.03200
Operating expenses for 1 mi	$0.15480

These figures are based on actual average working and can be considerably improved on by careful supervision. Tire mileage, for instance, can be bettered by the driver exercising precaution on bad roads.

We find that the field of the gasolene truck is limited only by the length of the highways. We have 5-ton trucks operating successfully in short hauls as well as long hauls. There is a very good description of a short haul job in the Engineering Record, October 26, 1912.

In our experience a comparison of costs with horse haulage is rarely asked for nowadays. There are many other benefits accruing beyond monetary saving. Users, for instance, are able to extend their territory and push sales at greater distance. Other users find the saving in time a valuable item. Still other users are operating trucks successfully where horses and mules are practically impossible. The extremes of heat and cold in our climate have rendered the horse an "unstable" animal, and the motor truck, electric or gasolene, is surely replacing him.

E. R. Gurney.[2] In Table 8, the operating expense of a two-horse team is given as $1559.24 per year, which, reduced to a ton-mile basis, assuming 12 miles per day, 300 days, loaded one way,

[1] Based on cost at present time.

[2] Knox Automobile Co., Springfield, Mass.

gives 33 cents per ton mile. This figure checks very closely with an average of horse-drawn costs as we have been able to compile.

In Table 12, the operating expense of a 5000-lb. electric truck reduced to a ton-mile basis is 27 cents per ton-mile assuming 24 miles per day 300 days. This is within 1 cent of the result obtained as an average of our 6000-lb. gasolene truck.

We have no data on electric operation nor on the lighter gasolene delivery systems. Our data begin where this paper leaves off and deal with the heavier class of units reduced to a cost per ton-mile basis.

Harrington Emerson. Reliable and adequate comparative records of costs of motor trucks and horse-drawn vehicles at the present time would be exceedingly valuable. The conclusions reached are not satisfactory, however, as the data are not standard. For instance, in estimating the cost of a truck Mr. Metz puts down interest at 2 per cent per annum which is not a legitimate industrial charge. Six per cent, perhaps 7 per cent, and in certain portions of the country even higher, would be the very lowest that ought to be charged. Depreciation is put down at 10 per cent. There is inadequate experience to justify the assumption that the depreciation of an electric motor truck is only 10 per cent per annum. In ordinary machinery we assume about 10 per cent a year for depreciation, and certainly on such an article as a motor truck, 10 per cent is too low for depreciation. On the other hand, when it comes to the horse-drawn vehicle, we have the statement that five carts, five horses and five men were displaced. How do we know that three men could not have done the work perfectly and three horses and three carts? Usually these horse-drawn vehicles are not operated at more than 60 per cent of possible rational efficiency. It is absolutely impossible to compare a truck operating probably at 100 per cent efficiency and a horse-drawn vehicle whose efficiency we do not know. In one table the horse-drawn vehicle is put down as costing \$1.92 a day and in the very next table the cost is put down at \$1.55, showing no standard of costs. What evidence is there that a horse-drawn vehicle ought to cost \$1.92 a day? If the \$1.92 is not correct, is merely a record of incidental cost instead of in any way being a standard cost, all conclusions drawn from the figures are invalidated.

Charles W. Baker. I do not see why 6 per cent interest should be charged on an investment in horses and only 2 per cent on an investment in electrical trucks. The figures on depreciation also seem open to criticism. Mr. Metz allows 15 per cent depreciation on the horse-drawn commercial vehicle, but I know of such vehicles that have been used for many years and are not yet worn out. He charges the same rate of depreciation on the motor vehicle, but my observation is that the depreciation of such vehicles is very rapid indeed. I think Mr. Metz's figures should be critically studied by anyone proposing to rely upon them for practical guidance.

The Author. Mr. Flanders recommends a reduction in speed, giving as his reason therefor, that it would greatly reduce vehicle and tire depreciation. While it is true that the speed reduction would reduce this depreciation, it should also be remembered that a necessary reduction in speed in congested city streets makes it imperative to obtain a higher speed at certain times in order to get mileage out of the cars sufficient to make them pay. The exact speed at which commercial vehicles should be run is open to question, but I believe that the present speed is about as nearly right as it can be made under present conditions.

Referring to the discussion by Mr. Emerson, it is my opinion that interest charges should be made to agree with the actual interest which any particular establishment has to pay. If the government can borrow money at 2 per cent, it is fair to charge 2 per cent interest on investment for government work. If private establishments have to pay, say 4 or 5 per cent, then they should charge 4 or 5 per cent interest on their investment.

The figures in my paper were given from actual experience, and the charges were therefore made to agree with the facts in the case.

It will be an easy matter for anyone desiring to install automobiles to separate the interest charges and make his particular interest charge agree with the interest which he will have to pay.

The remarks made by Mr. Baker hardly need any criticism, for it is apparent that he has not read the article correctly. A detailed examination of the article will show that for any given establishment the same interest is charged against electric trucks as was charged against horse-drawn vehicles, and in government

establishments the same thing is true. Mr. Baker evidently confused the figures by comparing the horse-drawn vehicles used in private establishments with the electric vehicles used in government establishments.

Referring to the depreciation charges, it is a well-known fact that the horse is not much good for heavy trucking service after five years of use, and the horse-drawn wagon is not much good for the same service after ten years of use, so that the 20 per cent depreciation on the horse, 10 per cent on the wagon, and 15 per cent on the harness represent average figures. The depreciation on electrics is, of course, not yet well understood, but there are plenty of electric vehicles in use at the present time which were purchased ten years ago, or more, so that the 10 per cent depreciation for this class of vehicles is on the safe side.

TEST OF A HYDRAULIC BUFFER

By Carl Schwartz, Published in The Journal for June

ABSTRACT OF PAPER

The paper discusses the performance of a hydraulic buffer for railroad terminal stations and the means used for the test. The results show the energy absorbed by the buffer under various conditions of train speed and weight and indicate how a buffer should be constructed to be least harmful to the train equipment.

DISCUSSION

F. H. Clark. One of the important elements in any device intended to absorb the shock or arrest the speed of moving bodies is the length of stroke or the distance through which the device operates. The disadvantage of the ordinary type of buffer or stop as used in railway service is the relatively short movement of the face of the buffer. In the hydraulic buffer described by Mr. Schwartz, this difficulty is overcome to a great extent by the stroke or working length of 11 ft., and the tests naturally show that desirable results are obtained. The device has the disadvantage, however, of occupying a considerable amount of space. The length over-all is not given, but it would probably not be less than 30 ft., or about 20 ft. more than is occupied by the usual type of buffer. This would be an important item in a large terminal, not only on account of the additional space required, but also on account of the greater distance between the train and the station.

Buffers as a rule are intended only for emergency use and are very seldom brought into action. It is generally desirable that such equipment be of such construction that casual inspection will determine whether or not it is in working order, and there might be some liability in cold climates of the device freezing or otherwise becoming inoperative without its condition being noticeable.

Arthur E. Johnson. This buffer could be designed so as to be

Presented at the Spring Meeting, Baltimore, 1913, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

similar to the simpler forms of brakes used to take up the energy of the recoil of guns, as follows:

First by ascertaining as nearly as possible the amount of pressure which a given train construction will stand as a resistance. Then the length of action of the buffer can be arranged as permitted by the space available and as required by the weight of trains. Cylinders may be arranged either horizontally or vertically to save space. They may be provided with a by-pass if necessary to handle trains very much lighter than the maximum. The lighter resistance thus provided would permit the same length of action for the light as for the heavy trains. And last, solid bumpers must, as before, be provided to prevent the pistons from bottoming whenever the energy is too great to be taken up entirely in the device.

Oil would seem to be a much more suitable fluid for this use than water on account of its greater viscosity.

H. A. Jensenius.[1] In traveling through Germany and England last summer, I saw a buffer in Düsseldorf and also one in England, the construction of which was similar to the one described by Mr. Schwartz, but the stroke I believe was not more than 8 ft. At crowded terminals space is very precious, and therefore if an apparatus of this kind could be built with a little shorter stroke and probably with a larger cylinder or higher pressure, it might be better adapted for the purpose intended.

Another point is the question of freezing. These buffers are filled with liquid and subject to low temperatures. Therefore, water would not be suitable. A device arranged with a closed pressure tank so as to confine the liquid and not to require any outside source of supply would in my judgment be more serviceable. In this case oil or any other non-freezable fluid could be used.

Philander Betts. The curves showing the results of tests of the stoppage of trains made by the use of this apparatus show the great importance of the draft gear. I would like to have the question answered, if it can be, as to whether note was made as to the types of draft gears and as to whether tests have been made with different types of draft gear to show the relative results in the stoppage of trains as indicated by the form of curve drawn by this apparatus.

The Author. The length of travel of the buffer piston is

[1] R. D. Wood & Co., Philadelphia, Pa.

largely influenced by the weight of the train striking the buffer and relatively little by the speed of the train, the speed of the train determining the pressure in the cylinder and thus the resistance against the train. The buffer is built for a maximum train weight of 1000 tons, and with about 11 ft. travel will be able to bring such train to a standstill. The length of the stroke could be shortened by increasing the pressure against the train with an increased liability of damage to the equipment.

Mr. Jensenius is correct in stating that buffers installed in Germany and England have a shorter working length, and the reason is that trains in Europe have smaller tonnage than in this country. The experimental buffer tested is the largest buffer of this type ever constructed, its total length being 30½ ft.

The suggestion is made to use another liquid than water. Inasmuch as the energy absorbed is all transformed into heat from a theoretical standpoint, water would be the ideal medium because it is the medium capable of storing the largest number of B.t.u. Practically, however, this feature is of little importance and the non-freezing qualities of oil or glycerine are more valuable. Water was used and disposed of to the sewer because the buffer is installed for experimental purposes, but for a permanent installation the suggestion to use a closed pressure tank to confine and circulate the liquid should receive careful consideration.

The tests were made irrespective of different types of draft gears and the curves in Fig. 8, which apply to a locomotive with four Pullman cars and a total train weight of 342.5 tons, show that a certain amount of energy was absorbed by the train itself due to the cars swinging back and forth during the impact. No doubt the type of draft gear has some influence upon the behavior of the train during the impact period.

SHADING IN MECHANICAL DRAWING

By Theodore W. Johnson, Published in The Journal for April

ABSTRACT OF PAPER

The object of this paper is to present a new rule for shading mechanical drawings, which comprehends the most important of the rules now used without their complexities and uncertainties and the controversies which arise from their use. The new rule is proposed with a view to reducing the art of shading to a precise and exact system in the interests of rapidity in the execution and reading of drawings and of their appearance.

DISCUSSION

Sanford A. Moss. It is questionable if shading really aids in reading a drawing. Fig. 1 would probably be as plain if it were unshaded, and Fig. 2 without other views could hardly be made plainer by any system of shading. Any mechanical drawing which depends upon the shading for its interpretation is likely to cause mistakes. Therefore, if we must use other means than shading to make the drawing plain there is no use going to the trouble of adding shade lines even though this trouble is very slight. That this is true is borne out by practice; 95 per cent of the mechanical drawings made today for regular shop use have no shading whatever. This has been a great evolution from the custom of ten or twenty years ago when shading was very prevalent. The writer has made a number of tests with actual mechanics, and a number of investigations as to the prevalence of shaded drawings in shop work. As a net result the decision was reached that mechanical drawings should not be shaded.

The view taken by Mr. Moss was expressed in various ways by other discussors, and the Editor has omitted repetitions of such statements.

Wm. P. Hawley. If the object of shade lining be to reduce the number of necessary views, and so make one view serve where

Presented at the Spring Meeting, Baltimore, 1913, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

two might otherwise be needed, the time saved in the drawing of views, will be consumed in the study and execution of the shading, and the drawing will not be so clear in the end. The mental effort required to interpret a drawing of one view with shade lines is doubtless greater than that required to understand the same drawing with an extra view and no shade lines, and there is far less chance for dispute in the latter case.

The author's closing sentence intimates that theory and practice are not now in accord, but will be when his new rule is adopted. When theory and practice are in conflict, it is safe to side with practice; present practice is for plain, legible, and unornamented shop drawings, with sufficient views of each detail to show all that shade lines might otherwise attempt. The best drawing for the shop man is the one that will give the most complete information in the simplest possible fashion; the one that can be made and interpreted with the least expenditure of time, and still leave no questions to be asked and no chance for disputes.

H. D. Hess. As the proper dimensioning of drawings requires that more than one view be given, anyone using drawings should read only one view as interpreted by the accompanying views. Failure to do this is quite noticeable on the part of students who not infrequently give up attempting to understand one view before examining the other views. Shading drawings for the use of students in engineering would only tend to increase their dependence on one view and would therefore be objectionable.

While not approving of any general adoption of shading in mechanical drawings, I believe the rule suggested by Professor Johnson would simplify shading and would prove satisfactory.

L. S. Burbank. In our drafting room no attention is paid to the shading of drawings; in fact, the rules explicitly state that no detail drawing shall be shaded. We standardize the strength of line of which the picture is made, and the strength of line of which the dimension and construction lines are made, so that the picture will stand out distinctly; these lines, however, are not made so heavy that they may not be conveniently and safely erased. Our layout drawings are generally made with differ-

ently colored inks, with the colors of the various details corresponding in the several views and with the full and dotted lines shown, generally, as if the detail showed alone.

But all this is special to our requirements; the general functions of the various styles or models of looms, etc., are so familiar that we need no emphasis put on the illustrative feature of the drawing, but are concerned principally with the changed form of the detail construction necessary to meet some new condition, and the colored ink enables the eye to trace and hold amid a labyrinth of other lines, the form of any particular detail. In ordinary shop working drawings I would not favor the shading of detail drawings.

In assembly drawings of relatively unfamiliar machinery, shaded work adds a depth and clearness, whereas colored line work shows it perfectly flat. Patent office drawing is a good example of the practicability and necessity of shaded work; and in practical machine design, particularly in assembly drawings where the mechanism is complicated or unfamiliar, shaded lines are generally an assistance. There are other cases, such as illustrative work where the intention is to beget admiration, which come under this class.

I think the rule for shading suggested by Professor Johnson is the best I have seen, and I shall certainly profit by it.

L. E. Osborne. The rules covering shading as given in the best text books on the subject ought to make their use clear. Prof. Gardner C. Anthony in his Machine Drawing covers the subject in the following concise paragraph:

> The only practical direction that may be given for the method of using them is to shade the right hand and lower edges of all surfaces, remembering that in the case of contact between surfaces, the line represents the surface nearest the observer. Where the surfaces are flush, as is the case between the stub-end of the connecting rod and the strap, the line must be fine. Never shade the intersecting lines between visible surfaces of the same piece, as illustrated by the division line of the faces of a bolt-head. Shade the lower right-hand quadrant of outside circles and the upper left-hand quadrant of inside circles. Do not permit the shade line to encroach on the surface which it bounds.

As Professor Johnson brings out in his paper, there is considerable variation in the use of shade lines. I believe this is due either to a drafting room holding to a method adopted a number of years ago, or to those in charge not requiring absolute uniformity of shading on drawings. Shading is by no means a dif-

ficult subject, and rules covering it, an example of which I have quoted above, make it clear.

Professor Johnson has covered his subject thoroughly and has ingeniously formulated a rule having both brevity and clearness. I believe this paper comes at an opportune time because it is unquestionably to the interest of both the engineering industries and profession that standard methods be used.

Luther D. Burlingame. In my experience with draftsmen I have found it difficult to bring about uniformity in the use of shade lines, due no doubt to the varying rules referred to in Professor Johnson's paper. As a matter of practice a large proportion of our work, when shaded at all, follows the general plan proposed by him, which has much to commend it.

I agree with the author in that reducing the number of shade lines to the minimum is desirable; practice at the Brown and Sharpe works is to use shade lines only for assembled drawings and sections, not using them at all on details or on tool drawings. The fact that tool drawings, and in many cases details, are made in pencil, blue prints being made directly from the pencil drawings, is another reason for not using shade lines for such drawings. While there is some advantage is using shade lines for the lower part of cylindrical objects in order that they may be distinguished from rectangular objects without an additional view, in practice this is of no great value because the variation in the work of different draftsmen is so great that it cannot be depended upon. It may be noted that while the rules of the patent office call for the light to come from the upper left-hand corner at an angle of 45 deg., a large proportion of the drawings do not strictly follow this rule. In fact it is an unusual experience to find any drawings which are entirely consistent in this respect. For these reasons I believe that the simple rule laid down in Professor Johnson's paper should be adopted as covering the best general practice and following what might be called "the line of least resistance."

F. W. Ives. I heartily approve of the author's proposal to change the direction of the ray of light to a position approaching the vertical. I believe that it will simplify materially the average draftsman's trouble in dealing with conflicting rules.

J. S. Reid. About the year 1907 I made an investigation into the general practice in drafting-room conventions. Thirty-five questions were embodied in a letter to 200 selected progressive chief draftsmen in this country, and in reply to one of the questions the almost unanimous answer, "never use shade lines" emphasized the conviction in my mind that shade lines on mechanical drawings are not essential to the proper reading of a correctly made working drawing. It is true that shade lines give a certain embellishment and relief from the flat to drawings that would seem to be very desirable at first thought, but the extra time required to apply them and the confusion in methods of application have been thought good reasons among others for abandoning them.

With the exception of the practice of the United States Government it is my belief that shade lines on mechanical drawings have been almost entirely abandoned, and in these days of scientific management and the elimination of all unnecessary movements it would surely be going backward to give the impression that the use of shade lines on mechanical drawings are the proper things.

The new rule suggested by the author seems to be rather vague and would need a good deal of explanation to go with it to make it clear to the average student or draftsman. "If a ray of light comes from a point almost perpendicular to the paper, how can the projection of that ray make a 45-deg. line, as at present?" is a sample question asked by students on reading the rule. A good many years ago when draftsmen were quite generally using shade lines, the most satisfactory rule was to shade the lower and right-hand edges of all flat surfaces in shadow. Of course the rule was not entirely satisfactory, but it was the most popular practice.

J. G. Matthews. From a practical standpoint the subject of shading in mechanical drawing seems to me to be one of minor importance. For several years, while in charge of the drawing room of a large concern in Michigan, I had all drawings shaded at a considerable expense of time and money. But since more than one view of an object is usually required in order to give the amount of the elevation or depression indicated by the shading, I feel that the other view or views are sufficient without shading. No shading is used in the East Technical High School in

Cleveland, and the pupils have no difficulty in understanding the drawings, though some of them are quite complicated; and if anyone were to be helped by the use of shading, it certainly would be students. I think that cases where it is worth while are very few.

THE AUTHOR. The discussion divides itself into two parts, on the proposed rule itself and on the desirability of shading in general.

The paper was not written with the intention of raising the general question, but since it has the discussion should be welcomed. On this question the writer wishes to take a middle ground.

The old practice of shading, whether necessary or not, was an economic waste. A rule to discard shading altogether is also wasteful, for it can easily be shown that in some cases the extra labor of executing the shading may save its equivalent many times over. The question is then a decision as to where to draw the line, and in deciding this the future history of the drawing must be considered. If a drawing is of a part whose general shape is well known and which may be handled only by a few persons, shading is entirely superfluous, for it is hardly more than a place to record dimensions.

Other drawings are to persuade engineers and laymen of the desirability of a new and unusual device or construction, or to teach students the construction of machines new to them. In such cases the little extra labor of shading may save its equivalent in time hundreds of times over. This is the explanation of the persistence of shading in text books, advertising books, patent drawings and professional papers. Many an engineer who is "down on" shading because he knows it to be a waste of time when applied to the detail drawings made in his office, will naturally adopt it when he writes something for a technical journal. He will then discover that in order to get his figures on a large enough scale for the very narrow printed page he must reduce the number of his views. If then a single view, shaded, can serve in place of two views, not shaded, he has gained, or rather the gain is to the user of the drawing in the ease of reading it. In order to have a rough and ready rule applicable in many cases the practice of shading assembled drawings and leaving unshaded detail drawings is spreading. It is a rule which follows the general idea that the simple drawing

for machinists' use does not require shading, and the complicated drawing for engineers does require it.

There is at present a tendency to fail to use shading even where there is distinct gain from it, due perhaps to the present state of confusion of rules. If the draftsman shading the drawing and the user for whom it is intended are not at one as to the meaning of a shade line in every possible case, it is clear that precision and time are lost and vexation caused which is attributable to the state of the art of shading, and not chargeable to shading per se. This I hope will be removed when a precise rule is generally adopted.

As regards the proposed rule of shading itself, it seems to be approved by some as simplifying shading and removing a "twilight zone" or debatable ground and making every question as

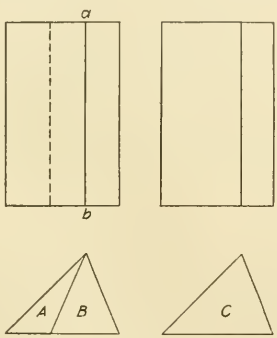


Fig. 14 Ambiguous Case of Shading

to shading one which can be answered with "yes" or "no." Mr. Osborne quotes a rule in Anthony's Machine Drawing as a concise paragraph, but to my mind it can only be interpreted in the light of a previous rule, defining the direction of light upon the object and it is subject to other criticisms. "Never shade the intersecting line between visible surfaces of the same piece." This rule is intended to be the same as rule V of the paper on Shading in Mechanical Drawing, but ambiguous cases can easily be devised. For example two wedges (Fig. 14), A and B, are placed together. Should the line ab be shaded? Apparently it should because the two visible surfaces belong to different pieces, while if the drawing were of a single wedge C, it should not. This is unreasonable. Also the statement: "shade the lower

right hand quadrant of outside circles," etc., violates general practice, by which a semicircle is shaded, if at all.

Mr. Ives criticizes the proposed rule as rather vague, asking "if a ray of light comes from a point almost perpendicular to the paper . . . can the projection of that ray make a 45-deg. line, as at present?" Of course a ray of light exactly perpendicular to the paper projects upon it only as a point, but one not exactly perpendicular, by no matter how small an amount, has such a projected direction, which indicates in what direction the ray of light begins to incline.

The new rule requires shading as if light were nearly perpendicular to the paper, but not exactly so. It leans slightly towards the original or traditional position of the light upon the drawing.

There are a number of points in mechanical drawing in which practice varies and which could well be standardized by a committee for the purpose. Shading is only one of these points. I suggest that members consider what demand there is for uniformity, and at some near future time take steps to create the proper committee either to act alone or with other societies, as may prove wisest.

FIRE PROTECTION

At the Spring Meeting of the Society in Baltimore, the entire morning session on May 22 was given over to the presentation and discussion of Fire Protection, and the following papers were read: Baltimore High-Pressure Fire Service, by James B. Scott, and National Standard Hose Couplings and Hydrant Fittings for Public Fire Service, by F. M. Griswold, which were published in The Journal for March; The Life Hazard in Crowded Buildings Due to Inadequate Exits, by H. F. J. Porter, and The Protection of Main Belt Drives with Fire Retardant Partitions, by C. H. Smith, published in The Journal for May; Debarment of City Conflagrations, by Albert Blauvelt, and Allowable Heights and Areas for Factory Buildings, by Ira H. Woolson, published in The Journal for June. The discussion follows herewith.

DISCUSSION

W. H. Kenerson said that he had been unable, after reading Mr. Porter's paper and listening to the discussion, to understand just what the author advocated. The first paragraph of the paper and the recommendation for legislation in the last would lead one to suppose that he pinned his faith to ready exits; whereas the discussion emphasized the importance of the fire wall. While both of these were admirable in their place, they did not afford complete protection either singly or when taken together.

Referring to the statement that people do not want to remain in a burning building more than three minutes, the speaker said that he happened to be present at the start of a very quick fire where the people in the building were reluctant to stay at all. They got out of the building by jumping almost as quickly as they could run to the side walls. Even with adequate exits it was plainly evident that danger could not be eliminated. In

Presented at the Spring Meeting, Baltimore 1913, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

buildings where operatives were working under crowded conditions some people would be burned or crushed before they could get out in case of a severe fire, even if the walls were open all the way round, owing to the furniture, machines, etc., being closely grouped. The panic following an incipient fire was often worse than the fire itself and did more damage. Moreover, in some of our large cities, the streets in the neighborhood of office buildings and factories were so narrow and would be so hemmed in by the crowds rushing toward the building in case of a fire that it was improbable that there would be room enough in the street to accommodate the operatives who were leaving. This was certainly true of some loft buildings in New York City.

Regarding the use of the fire wall, while it was of great value in certain cases and places, it was not altogether dependable. Was it not conceivable that fires could start on both sides of a partition at once? There were many conditions under which a fire would rapidly spread to both sides of a partition even if it did not start on both sides, as for example in a flash fire.

The author very properly said that sliding doors inside of partitions were dangerous; but what of swing doors? These should always open outward, but what was "outward" in a partition that must be used in both directions? Where communication was established between adjacent buildings even, it was inevitable that one of the doors would open the wrong way.

There was only one paragraph in the paper about preventive methods through the use of automatic apparatus in conjunction with other things for preventing fire at the start. It was unfortunate that this was not included in a paper of the general scope of the one under discussion.

He believed that it would be impossible to enforce the legislation recommended in the last paragraph of the paper to prevent architects from designing buildings which could be emptied in three minutes. Before construction such a matter was a question of opinion rather than fact. Moreover, operatives could not be prevented from crowding or becoming panic stricken in the event of a fire and it was doubtful under such circumstances whether many a properly designed building could be emptied in 3 minutes even if it were possible to enforce the first recommendation.

Henry Hess. I am neither an insurance man nor a sprinkler man. I have had some experience putting up factory buildings

and running the establishment afterwards. One of my most interesting experiences of that character I had in Germany where I was building a large tool works. The first thing I ran afoul of was the law. I bring this up particularly because Professor Kenerson has indicated that it was his belief that adequate legislation was absolutely impossible, if not as to securing it in the first place, then as to its later enforcement. Now that is a question of the will of the community. If the community really desires enforcement of law the community will see to such enforcement. Firewall partitions such as Mr. Porter advocates are very useful. In the case of the German factory partitions were installed in certain cases and were not insisted upon in others; but there was an insistence upon one other thing of possibly far greater importance. The authorities determined a central point for each floor area, considered the number of people at work in that area, and then insisted that there must be an adequate fireproof staircase within a certain distance of that central point. The size of the stairway was made to increase with the increase of that distance, which latter was not permitted to exceed a certain limit. Moreover, a stairway had to be provided at not merely one end, but at two ends at diagonal corners so that there was a possibility of reaching a stairway in two directions from a central point. The law does not permit overcrowding. Such conditions as obtain in New York City loft buildings would not be tolerated in the countries from which the people who run the industries in these lofts have come to us. Why should our communities grant them such permission here? Panic cannot be altogether guarded against in the construction of a building. Sprinklers do not constitute a full safeguard. In fact if you were to send down a douche of water upon an excitable woman when she smells smoke or sees fire you would most certainly not cool her down. Provide what safeguards you will, always keep the crowds down to a point where even panic stricken people cannot seriously jam.

Geo. I. Rockwood. As one interested in the general subject of fire protection, I have followed closely the fire statistics of the last seven or eight years as given out by the National Fire Protection Association and the Factory Mutual Fire Insurance Companies. I have also had experience with the manner in which automatic sprinklers operate to save human life, having

been responsible for the installation of many hundreds of thousands of sprinkler heads; so that with that experience back of me I want to say that no one so far as I know has really done more to convert the rather obstinate architectural profession, as well as the equally obstinate members of the profession of fire protection engineering, to the use of this very obvious device for getting operatives and others out of a burning room and into a place of safety than has Mr. Porter.

The way of the reformer is proverbially difficult, but it seems to me that those responsible for the design of loft buildings have been particularly slow in appreciating Mr. Porter's work. Very likely the reason for this will be found in Mr. Porter's scarcely concealed contempt for the automatic sprinkler as a life-saving device, but neither Mr. Porter nor anyone else has yet made any proper inquiry into the history of automatic sprinklers, considered solely from the point of view of their use as life savers. They have been regarded altogether as property savers, and are installed in buildings for that purpose. It is perfectly clear that every time a sprinkler operates successfully in a building containing human beings it is potentially a life saver. The question narrows down, therefore, to the effect of sprinklers in preventing panic conditions in buildings. Do they prevent panics or can they be made to prevent them? We need a little further light on this subject before we can dogmatize to advantage either way, but I feel confident that the solution of the problem of saving human life is a function equally of the use of Mr. Porter's centrally located incombustible partitions and the proper use of automatic sprinklers.

In the average case of a fire extinguished by automatic sprinklers three or four heads are all that open to effect the result. In the case of quick flash fires an entire roomful of sprinklers may open, seemingly at once, without any appreciable interval of time between the setting of the fire and the operation of the sprinklers. The question naturally arises, would such instant out-pouring of water be an advantage or a disadvantage to a room more or less crowded with operatives? No sane man would take the ground that he would rather be in such a room, under those conditions, without sprinklers. In a recent case where a flash fire occurred in the first floor of a three-story factory filled with people on every floor, a can of material in which gasolene was an ingredient took fire, and the curious fact resulted that although the room was

not a particularly large one, and there were many men at work in it, not a man got out of the room without getting wet. They said afterwards that there seemed to be no interval of time between the instant when the can flashed up and the subsequent out-pouring of water from all of the sprinkler heads in the room.

It might be thought that where a factory has a good deal of material out of which, say, straw hats, or lingerie, are made the rapidity with which the fire, once started, would propagate would insure the injury of everybody in the room. Such a view would fail entirely to take into account the fact that when the fire starts the heated gases almost instantly rise to the ceiling where they proceed to mushroom out and open the sprinkler heads one after another much faster than the fire can propagate itself in the material on the floor. This is not a matter of speculation; it is an observed fact.

There are classes of buildings in which there are so many concealed spaces in the wooden walls, wooden partitions and wooden floors, that a heavy fire may conceivably get strong headway in some concealed space before it showed itself. Under such circumstances the sprinklers operate at a disadvantage and merely act as a check to the spread of the flames until the arrival of the fire department. But even then they often make it possible for the firemen to carry their hose to the very center of the fire, and thus are the primary cause of its final extinguishment.

Mr. Porter would do well to add to his crusade in favor of a central fire resistant partition, with separate means of egress on opposite sides of it, a further demand for the installation of automatic sprinklers, and he will be surprised to see how much more quickly his original effort at reform will succeed.

Harrington Emerson. In making comparative investigations of American and foreign cities what strikes one most is the much lower fire loss in German cities than in American cities. The reason is that different ideals have been pursued. Our ideal is to get there immediately. In an international test of different fire companies at Berlin about 20 years ago it took the Americans 20 seconds to come out, couple up the hose and begin to play the water, while it took the Germans over 8 minutes to prepare to fight the fire. Nevertheless the fact remains that the fire loss in Germany is small compared to what it is in this country. It is not because they have buildings that cannot be burned, because recently in Hamburg a number of incendiary fires occurred with

severe losses. But the principle of the Germans is to prevent fire, not to fight it after it is started; while we have gone the limit in fighting fire after it is started. We are away behind the rest of the world in preventing fires before they start. Switzerland is a country of wooden houses yet the per capita fire loss there last year was only 2 per cent of the American per capita loss.

F. B. Gilbreth. There is no doubt but that standardization is the thing more than any other one thing that will reduce the number of fires; but let it be standardization for the prevention of fires rather than means for killing them after they are started. Fires are the product of ignorance. A very small portion of architects, and a still smaller portion of engineers, know how to build a building that will not burn up. There has been a paper written on the subject by Charles Whiting Baker, in which he adds not only to the statistics of dollar loss but also to the statistics of human loss. If I remember correctly there is a badly burned human being on the theoretical road from Chicago to New York every thousand feet, and every mile there is a man who has lost his life. This theoretical street consisted of a double row of six-story buildings, and these buildings burn up every year in the United States.

I have seen many of the big conflagrations in this country: Toronto, Rochester, Baltimore, San Francisco and Sioux City. A careful examination of all those ruins shows beyond any possibility of doubt that if we tried to build buildings that would burn up we really could not do a much better job. Reports of experiments carried on by Professor Woolson in New York City during the last ten years contain much valuable information upon this subject.

We face an entirely new situation today with the advent of concrete, which when made with the proper aggregates, such as trap rock and the right kind of sand, is of tremendous assistance in resisting the spread of fires. In fact, we are not depending on any of the old types of construction and fireproofing schemes for preventing the spread of fires. Let us have buildings, to begin with, that will not aid the spread of fire.

I suggest for the consideration of the Society an exhibit room to which engineers, architects and insurance companies may come and satisfy themselves that there is not a single thing in construction today that cannot be made better and quite as cheaply out of absolutely incombustible material.

James B. Scott. Education, it has been said, should properly begin with one's grandparents, and undoubtedly the time to begin fighting a fire is before it begins. But granting that the "eugenics" of fire fighting have been properly observed, there will always remain the possibility of accident or incendiarism, giving rise to a hand-to-hand conflict with man's ancient enemy. The ships that can deliver more shells and heavier shells, in a given time and within a given area, and can begin delivery a few minutes earlier than the enemy, are usually awarded the victory in a modern naval engagement. The fire-fighting system which can deliver enough water, at a suitable pressure, just where it is needed, and can begin delivery in the fewest possible minutes after the discovery of a dangerous fire, is approaching the coveted 100 per cent efficiency in its limited field, as distinguished from the wider province of fire prevention.

H. F. J. Porter. There is no need for closing the discussion on my paper, which simply points out the inadequacy and danger of the stairway. Such criticism as has been made has been answered in the discussion itself.

PRACTICAL OPERATION OF GAS ENGINES USING BLAST-FURNACE GAS AS FUEL

By Charles C. Sampson, Published in The Journal for May

ABSTRACT OF PAPER

The paper discusses the following features upon which the operation of gas engines using blast-furnace gas as fuel depends: present methods, improved apparatus, gas mains, suggested improvements in scrubber designs, gas regulation, protection from freezing, signal systems, protection from explosions, and the value of operation records.

Under the engines themselves are considered the operators, air starting system, water jacket cleaning, cylinder oil, engine oil and engine oil systems, ignition and prematuring.

DISCUSSION

Fred. H. Wagner. From reports received, I find that with practically the same character of apparatus, (*a*) dry dust cleaners, (*b*) some sort of static towers like the Czchokke or Steinbardt, and (*c*) the Theisen washer, the final cleaning varies between 15 cents and 62 cents per 100,000 cu. ft. of blast-furnace gas cleaned; this being based on $10 per 1,000,000 gal. of water and 1 cent per kw-hr. The great discrepancy in these final figures has led to the question as to why such discrepancies should exist. The answer is a difficult one to give; for instance, at one blast furnace the final cleaning based on 100,000 cu. ft. of gas costs 61 cents, at another 47 cents, at another 42 cents, at another 25 cents, at another 20 cents, at another 19 cents, and at another 15 cents.

Mr. Sampson mentioned that some new apparatus, which is along the line of mechanical disintegrators, claimed to use about 20 gal. of water per 1000 cu. ft. of gas for the whole cleaning process, and to operate on less power than the Theisen washers;

Presented at the Spring Meeting, Baltimore, 1913, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

also that with the present process from 90 to 100 gal. are used for the entire cleaning process.

At the last meeting of the West of Scotland Iron and Steel Institute, B. W. Head read a paper[1] giving the results of his visit on the European continent, for the purpose of examining blast-furnace conditions. After calling attention to the failure of the Scottish steel manufacturer to take advantage of the improved methods adopted in Germany, Belgium and France, he takes up the subject of washing blast-furnace gases for gas-engine purposes and points out the difference in the methods practised in the British Isles and those used on the Continent, mentioning especially the Feld vertical centrifugal washer for the cleaning of gas.

Besides the Theisen washer mentioned by Mr. Sampson, and the Feld washer, there is a third, the Schwarz. The last two are attracting a great deal of attention in Europe in connection with this process. They require less power than the Theisen washer, and the Feld requires considerably less power than the Schwarz.

At the blast furnaces in Donawitz, where 1,600,000 cu. ft. of blast-furnace gas is treated per hour, the total power with the Schwarz washers amounted to from 124 to 128 h.p. At the blast furnaces in Pompey, France, of exactly the same capacity, the Feld washers used from 50 to 55 h.p., the power given including the necessary power for exhausters. Unfortunately in my data on the Schwarz washers, I have not the power of the washer and the exhausters separate; however, for the Feld washers, the washer power amounted to from 15 to 20 h.p. and for the exhausters 35 h.p. This great difference in power requirements is due to the fact that the Feld washer throws absolutely no back pressure—the washer operating with an even gage on both the inlet and outlet, while the Schwarz washer throws a considerable back pressure.

In speaking of the quantity of water required for cleaning the gas, I would mention that two factors enter into this discussion: (*a*) being the cooling of the gas to a temperature which retains the heat units and at the same time reduces the volume of the gas to the smallest possible compass in order to avoid large gas-engine cylinders. The cooling of the gas is a thermal question, and

[1] The Journal, West of Scotland Iron & Steel Institute, vol. 19, Nos. 6 and 7, pp. 266 and 319.

the amount of water required is determined by the amount of water vapor which carries the heat contained in the gas. This amount of water would be necessary, no matter in what sort of washer the gas is cooled, as a certain number of heat units must be extracted, and the water cannot take up any more than its temperature will permit.

With a temperature of 500 deg. fahr. and treating 5,400,000 cu. ft. of gas per hour, with the gas coming from two furnaces, reducing this temperature to 86 deg. fahr. requires about 31 gal. of water per 1000 cu. ft. of gas. The cleaning of the gas after the water is cool, is done by the hot water from the cooling chambers, about one-quarter of the amount given above, or 7½ gal., being run into the washing chambers of the Feld washer. For this purpose the Feld washer is built in seven sections, the upper four acting as cooling chambers and the lower three as cleaning chambers. It is a known fact that if an impalpable powder be placed on a floor, and cold water is thrown on it, the water forms globules on the surface of the particles, but if hot water is thrown on the powder, it immediately mixes and forms a mud. This is the principle on which the Feld washer is operated. Each one of the sections of this washer contains a series of perforated truncated cones, the lower ends of the cones dipping into the water, and by the revolving of these cones, given a periphery speed of 1600 ft. per min., the water is carried up inside these cones and hurled out through the perforations in a finely divided spray.

Those conversant with dust washing will admit that the proper method to wash dust out of gas is to bring the gas into intimate contact with the smallest particles of water possible, and this is done in the Feld washer.

In a lead smelting furnace, where these Feld washers are in use, these washers recover six tons of dust containing from 80 to 100 per cent lead every 24 hours and entirely remove the lead particles, which formerly escaped into the atmosphere to the detriment of the surrounding vegetation.

In the blast-furnace plant at Pompey, France, where the Feld washers are also in use for cleaning blast-furnace gas for gas-engine purposes, I would state that prior to the use of the Feld washers, it was necessary to open up the valve chests on the engines about once every ten days and remove the accumulated dust; since the installation of the Feld system, it has become necessary to open up the valve chests only about once every three

months. These washers have been in continuous operation for about 30 months without one moment's shutdown for cleaning or repairs, the washers being self-cleaning, the water carrying the dust leaves the washer in the shape of a mud, which is easily handled by means of centrifugal pumps.

The aim of the modern engineer is to reduce the cost of operation and at the same time to secure better results. This has led to the Feld washer, and I would earnestly recommend anyone treating furnace gases for gas-engine purposes to investigate the Feld washer before purchasing other apparatus, as the first cost of the initial installation, as well as the ground space occupied is less than with the use of static towers.

A washer of the Feld type has just been placed in the works of the American Smelting and Refining Company at Maurer, N. J., for the purpose of removing the last traces of gold, silver, lead and silenium from the gas which comes from the mud cupel furnaces.

In order to clean 100,000 cu. ft. of blast-furnace gas for gas-engine purpose, or so that the final gas does not contain more than 0.01 grains of dust per cu. ft. and to reduce the temperature from 500 deg. to 86 deg. fahr. would cost with the use of nine Steinbardt coolers with the necessary Theisen washers, less labor and exhauster power, 14½ cents; with nine Steinbardt coolers and Schwarz washers, 11 cents; and with three Feld primary and two Feld final washers, 5.2 cents. This is based on the cost of water at $10 per 1,000,000 gal. and power at 1 cent per kw-hr. in a plant capable of handling 5,400,000 cu. ft. of gas per hour.

The author did not desire to present a closure.—EDITOR.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Particular attention is called this month to the beginning of an abstract of the work of Professor Alliévi on the theory of water hammer, which immediately upon its publication in the original attracted wide attention among hydraulic engineers in France, Germany and Switzerland. The abstract is made from a French translation because the original Italian publication is not available. It appears that the problem of water hammer in the modern hydraulic installations working with high heads and large masses of water, is seriously interesting the European engineers, if one may judge from the number of articles on this question. Thus, besides the Alliévi article, an abstract is also given in this issue of The Journal of an article of de-Sparre, and in an early issue there will appear an abstract of a report on the same subject by the French Commission on Turbines.

THIS MONTH'S ARTICLES

A. Magnan shows that valuable data for the construction of monoplanes may be derived from an examination of the "design" of birds, particularly of birds of prey, and also brings out the interesting fact that, with the exception of their lengths, the present day monoplanes, in their proportional dimensions, approach very closely the bird of prey. Gastambide and Levavasseur describe the construction and explain the principle of their aero-parachute, a flying machine which, with the engine stopped, would slowly drop to the ground like a parachute. Brief abstracts on the Joukowski supporting planes and Canovetti experiments on resistance of air to moving bodies are also to be found. The section Hydraulics is particularly interesting this month, there being, in addition to the above-mentioned articles of Alliévi and de-Sparre, reports of articles on turbine regulation and on axial flow pumps. In the section Mechanics are given articles on graphic determination of moments by a combination of the Nehls and funicular polygon methods, as well as a brief statement concerning the calculation of shafts having several bearings. A discussion of steam consumption of exhaust

steam and combined turbines by Roeder indicates, among other things, the possible use, in connection with that class of turbines, of graphically determined lines instead of curves determined experimentally, for guarantee purposes of live steam consumption. Other articles describe an apparatus for preheating feedwater by exhaust steam and the construction of a sectional boiler adapted to be used with lignite briquettes. Some test data as to centrifugal pumps, and a brief discussion as to their advantages and disadvantages as compared with reciprocating pumps is also given. In the section of Strength of Materials and Materials of Construction, Fremont explains the peculiar formation of uniform folds in metal tubes compressed to the point of collapsing, the other articles indicating the importance of the presence of nitrous compounds for the production of rusting of iron; an etching solution for determining defects in autogenously welded pieces, and data of compression tests of vulcanized fiber, hard rubber and metal for stuffing box packing.

Aeronautics

DATA FOR THE CONSTRUCTION OF AN IDEAL MONOPLANE TAKEN FROM CHARACTERISTICS OF BIRDS (*Données pour la construction d'un monoplan idéal tirées de charactéristiques des Oiseaux*, A. Magnan, *Comptes rendus de l'Académie des Sciences*, vol. 156, no. 23, p. 1746, June 9, 1913, 2½ pp., *t*). The author asserts that the mechanical characteristics of the flying apparatus of birds varies in accordance as they use habitually sailing, soaring or flapping flight. Birds of prey, preferably using soaring flight, have a large surface of wings, small motive plant represented by undersized pectoral muscles, wide span across the wings, fairly wide wings and long tails, while birds using flapping flight mainly, such as sparrows, pigeons, etc., have wings of small surface, powerful pectoral muscles, short span across the wings, wide wings and fairly long tails. The type of bird nearest approaching in its flight to the monoplane is the bird of prey, and the author investigates what would be the dimensions of a monoplane possessing the same characteristics as a bird of prey, assuming an entire proportionality of dimensions. The author has found the following relations for daylight birds of prey:

Ratio of surface of wings, in cm. sq., to the surface of the body $S = \sqrt[3]{P^2}$ 23.2
Ratio of weight of wings, in gr., to the weight of the body P 197
Ratio of span across the wings, in cm., to length of body $l = \sqrt[3]{P}$ 13.3
Ratio of width of wing in the middle, in cm., to length of body $l = \sqrt[3]{P}$ 2.36
Ratio of length of tail, in cm., to length of body 2.60
Ratio of actual length of body to $l = \sqrt[3]{P}$ 5.9

The author proceeds to show that an ideal monoplane corresponding in its characteristics to a bird of prey, and having a weight, in flight, of 500 kg. (1100 lb.), would have the following characteristics:

Wing surface	14.70	qm	157.3	sq. ft.
Weight of wings	98.5	kg	216.7	lb.
Span across the wings	10.5	m	34.4	ft.
Width of wing	1.87	m	6.13	ft.
Length of tail	2.06	m	6.75	ft.
Length of apparatus	4.67	m	15.3	ft.

This shows that the apparatus designed in accordance with the scheme evolved from a study of birds would be shorter than those used at present, but in other characteristics would approach the bird of prey type more closely than usually believed. This method facilitates the proportioning of a monoplane for a given weight, but, in the form given, applies only to machines designed to fly above ground (i. e., to the exclusion of flying boats).

Experiments on the Resistance of air to Bodies Moving in it (*Expériences relatives à la résistance au movement des corps dans l'air*, Canovetti, *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, vol. 119, no. 5, p. 633, 2 pp., *e*). Brief report of the experiments on air resistance. The experimenter used a four-cycle carriage running on an inclined funicular railroad (while the latter was not in commercial operation), with a bamboo scaffold carrying different planes, from 2 to 8 qm. (21.5 to 86.1 sq. ft.) area, at speeds from 5 to over 17 m. (16.4 to over 55 ft.) per sec. It has been found that the resistance is not proportional to the square of the speed, but varies in accordance with the formula $0.4\ V + 0.03\ V^2$. The author of the report, M. Lecornu, criticizes the method used by Canovetti, and points out various possible sources of error, recognizing however the main advantage of the method of Canovetti, that it does not require elaborate apparatus.

Joukowski Supporting Plane Problems (Two articles: On Pressure Distribution Along Joukowski Planes, *Über die Druckverteilung längs Joukowskischer Tragflächen*, Otto Blumenthal, *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 4, no. 10, p. 125, May 31, 1913; and Graphic Construction of Joukowski Supporting Planes, *Graphische Konstruktion Joukowskischer Tragflächen*, E. Trefftz, ibidem, p. 130). The first article contains a mathematical investigation of pressure distribution along Joukowski supporting planes, as well as a discussion of their characteristics. The author shows among other things that in this plane there is a powerful suction action along the upper surface of the plane which is the main element in the supporting effect of the plane, the pressure on the lower surface contributing to it only in a moderate degree. The second article contains a description of a method for constructing a Joukowski supporting plane graphically.

Aero-parachute (*Sur un Aéroparachute*, Levavasseur and Gastambide, *Comptes rendus des séances de l'Académie des Sciences*, vol. 156, no. 23, 1748, June 9, 1913, 3 pp., 4 figs., *d*). The apparatus described is an aero-

plane with variable surface and incidence which can fly on all descending trajectories acting as a parachute. It consists of two wings and a symmetrically placed body, the wings being of variable area, and consisting each of three parts: a fixed part of trapezoidal shape, say (2 + 2) : 2x5, or 7.5 qm (80.6 sq. ft.) area, and two movable parts, each formed of two group of shutters. The entire wing, developed, has the form of a semicircle, of radius 5 m (16.4 ft.), and area 37.5 qm (403.5 sq. ft.). These wings are articulated on a frame, and can take any desired position, from horizontal to vertical, the frame in its turn being articulated on the body of the machine which permits varying the angle of the body with respect to the wings from 0 to 90 deg. The manoeuvring with the four folding wheel sections as well as the variation of the angle of incidence and of V are independent of one another, but a special apparatus may make all these operations coördinated in view of producing parachute flight and

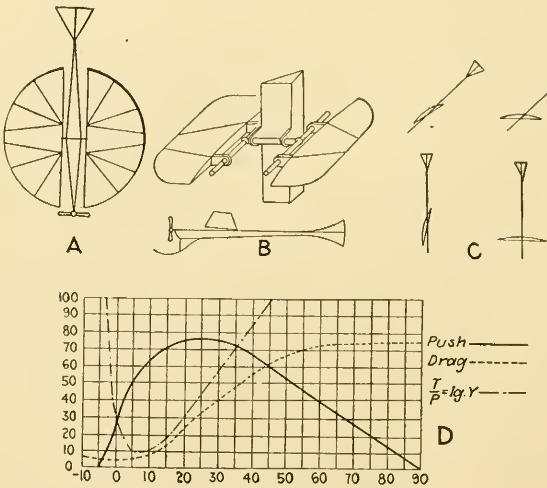


FIG. 1 AERO-PARACHUTE

parachute state. The apparatus has no rudder, and is steered by varying the folding sections of the wings (cp. Fig. 1, A and B).

In the following a study of the parachute state is presented, the variations of folding, incidence and V being coördinated, the incidence varying from 10 to 30 deg., surface of wings from 15 to 75 qm (161 to 806 sq. ft.), and V decreasing 4 deg. When the incidence varies from 30 to 90 deg., the surface of the wings remains constant at 75 qm (806 sq. ft.), and V decreases 20 deg. From the curves of drag and push (Fig. 1, D), with the area of surface only varying, the direction of the body being always that of the air stream lines, it is apparent that when the angle of incidence varies from 10 to 90 deg., the angle γ (angle between the resultant and vertical line) varies in the same sense, and takes practically the same values; it appears further that to each value of γ there correspond two

values of the ratio $\frac{t}{P}$, one for an angle of incidence less than the most favorable, and the other for one greater than the most favorable angle of incidence. There are apparently two ways of descending: one, volplaning, the incidence of the wings essentially that of the trajectory, this being the way of landing of the present aeroplanes; the other, parachuting, with the wings remaining horizontal, as in the aero-parachute proposed by the authors (cp. Fig. 1, *C*). The tests made by the authors have shown that the resultant intersects the chord of the wing at a point which varies as a function of the angle of incidence, the displacement of this point of intersection being favorable to the maintenance of stability for variations of angle of incidence from 10 to 90 deg., but dangerous for 10 to —5.5 deg.; in the latter case the stability is "differential," and is maintained by the rudder and balancing planes solely. Only angles of incidence from 10 to 90 deg. are to be used in the apparatus designed by the authors, additional stabilization being provided by locating the center of gravity of the apparatus on the prolongation of the resultant.

Hydraulics

Theory of Water Hammer (*Théorie du coup de belier*, Professor L. Allievi, *Bulletin technique de la Suisse Romande*, vol. 39, no. 11, p. 121, June 10, 1913, 3 pp., serial article, to be continued. *A*). A discussion of the theory of water hammer. In another investigation the author has shown that the variations of load along a water conduit travels with a speed a given by the formula:

$$\frac{1}{a^2} = \frac{\omega}{g}\left(\frac{1}{\epsilon} + \frac{1}{E} \cdot \frac{D}{e}\right) \qquad [1]$$

where ω = the density of the liquid; ϵ = modulus of elasticity of the liquid; E = modulus of elasticity of the material of the walls of the conduit; D = diameter of the pipe, and e its thickness. If in formula [1] it be assumed that $\omega = 1000\ kg/m^3$ (62 lb. per cu. ft.) and $\epsilon = 2.07 \times 10^8\ ng/m^2$ (294,355 lb. per sq. in.) the following is obtained:

$$a = \frac{9900}{\sqrt{48.3 + K.D:e}} \qquad [1a]$$

where K = 0.5 for wrought iron and steel pipes, and K = 1.0 for cast iron pipes, the value of a varying between 600 and 700 m/sec. (1968 to 2296 ft. per sec.) for thin-walled pipes of large diameter, and 1200 to 1300 m/sec. (3936 to 4264 ft. per sec.) for thick-walled pipes of small diameter. The author formerly showed that the variable load y (in meters of water), and the variable velocity v in any section of a conduit of variable output, are expressed by the following equations:

$$y = y_o + F + f \text{ and } v = v_o - \frac{g}{a}(F - f) \qquad [2]$$

t being time, and x the abscissa of the section under consideration measured along the axis of the conduit in a sense opposite to that of the velocity v, which is equivalent to saying that F represents a variable positive or negative load traveling in the direction $+x$ with a velocity a, while f represents a variable load traveling with the same velocity a in a direction $-x$.

With certain limit conditions introduced, equation [2] may be used for determining the values of F and f for each instant t and each abscissa x, so as to permit the numerical solution of all problems concerning variable flow of water in conduits. In particular, in the case of a conduit of length L fed at its upper end (abscissa $= L$) from a reservoir (constant level), and having at its lower end (abscissa $= O$) an outlet opening of which the cross-section may be varied by means of pipe closer, the values of the function f in any section of abscissa x and at any instant t, are always equal in magnitude but opposite in sign, to those of function F for the same abscissa, but for the instant preceding t by $2\ (L-x) : a$, which is the time required to travel twice, at velocity a, through the part of the conduit of length $L-x$, separating the section of abscissa x from the feed reservoir. This may be expressed by the equation:

$$f\left(t+\frac{x}{a}\right)=-F\left(t-\frac{x}{a}-\frac{2\ (L-x)}{a}\right)=-F\left(t+\frac{x}{a}-\frac{2L}{a}\right) \ldots\ldots\ldots\ldots [3]$$

and may be interpreted by saying that the phenomenon develops as if each overload F traveling from the outlet orifice towards the reservoir (direction $+x$) were reflected from the reservoir with a negative sign and sent back towards the pipe closer (direction $-x$). The values of perturbations (i. e. water hammer) in any section of abscissa x produced by moving the pipe closer, become therefore fully known as soon as the perturbations are determined in the section $x = o$, at the pipe closer, where

$$f(t)=-F\left(t-\frac{2L}{a}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3a]$$

By means of the Bernouilli equation applied to the liquid jet blowing from the outlet opening, it is very easy to calculate series of numerical values of F for the abscissa $x = o$ and for instants t separated from one another by intervals $\frac{2L}{a}$ or, with F known, it becomes easy to calculate f for the same abscissa and time $\frac{2L}{a}$ seconds later. The author calls the interval $\frac{2L}{a}$ the *length of the phase*, and designates it by μ.

On the basis of the above stated fundamental conceptions, the author proceeds to establish a theory of water hammer, characterized among other things by the following three novel features: (a) systematic use in all formulas of *relative values* of variable quantities, i. e., the ratio of their absolute value to their initial value as a unit; (b) selection of velocity of discharge or rather its relative value, as the main variable instead of load, the new variable being obviously equal to the square root of the relative value of load; (c) selection in all cases of μ for unit of time, this permitting the reduction of all conduits to a common unit and leaving out of calculation the influence due to the length of conduit. By these means the laws governing the water hammer phenomena may be expressed as functions of only two parameters, one, which the author calls *conduit characteristic* and designates by ρ, completely defining the conduit when operating at uniform rate, and the other μ indicating the speed of operating the pipe more closely.

Axial Flow Pumps (*Über Axialpumpen*, Professor Wagenbach, *Zeits. für das gesamte Turbinenwesen*, vol. 10, nos. 16 and 17, pp. 241 and 232, 7 pp., 12 figs., *ct*). Owing to lack of space, only the main conclusions of this very interesting investigation can here be given. The author shows that for each axial flow turbine there is a minimum quantity of water below which stable operation of the pump cannot be secured (lower limit of regulation). This limit of stability lies all the deeper as the ratio of peripheral speed to the head is greater. It is, therefore, of advantage to build axial flow pumps with large peripheral speeds, even though this may be done at a sacrifice of possible efficiency. The practical possibilities of axial flow pumps do not appear to be great. The simplicity of construction is an argument in their favor; their disadvantages lie in limited regulation, and low starting head. In addition to that there is another possible disadvantage, and that is higher friction and eddy losses. In radial flow pumps it has been established that the efficiency is the greater, the smaller in proportion to the useful output are the external surface of the runner and its peripheral speed. In axial flow pumps the surfaces under friction are hardly smaller than in radial flow pumps, while their average speed is much greater. It is therefore likely that the losses are also proportionally greater. Further tests and data are, however, necessary before it may be said that axial flow pumps are practically inapplicablo.

Regulation of Hydraulic Turbines (*Note sur la Régulation des turbines hydrauliques*, Professor Ch. Dekeyser, *Bulletin technique de l'Association des Ingénieurs sortis de l'École Polytechnique de Bruxelles*, vol. 11, Ser. 2, no. 6, p. 203, April 1913, 8 pp., *t*). Discussion of the principal cases of hydraulic turbine regulation. The author defines regulation as the totality of processes for insuring the operation of a turbine at constant angular speed, while certain conditions of operation vary. These variations in the conditions of operation may consist in variation in the volume of flow of water, of the head, and useful resistance. It is assumed that the purpose of the turbine plant is not affected by these variations, and that therefore the angular speed ω and the linear velocity of drag w are to remain constant. The following notation is used: $W =$ useful power taken from the shaft; $\triangle =$ specific weight of water; $Q =$ volume of water flowing across the turbine; $\rho_1 =$ internal efficiency of the receiver; $\rho_2 =$ mechanical efficiency; $\rho_3 =$ coefficient depending on losses due to shocks which may occur at the entrance to the receiver (the author has elsewhere shown that with the turbine running under normal conditions at full load, $\rho_3 = 1$); $H =$ the net head of water. The following relation exists between these quantities:

$$W = \triangle \rho_1 \rho_2 \rho_3 QH \qquad [1]$$

On the other hand, if the moment of resistance on the driving shaft be designated by M, then $W = M\omega$. Hence:

$$\omega = \frac{\triangle \rho_1 \rho_2 \rho_3 QH}{M} \qquad [2]$$

If it be made obligatory that the speed be constant for all conditions of operation, then *the quotient* $\frac{\triangle \rho_1 \rho_2 \rho_3 QH}{M}$ *must remain constant for all*

useful loads on the turbine shaft, this permitting the establishing of the following rules:

a If the moment of resistance M changes, either Q or H, or both these quantities, must be varied in such manner that the product QH varies proportionally to M;

b If either the volume of flow or the head happen to vary, M must be changed in such manner as to maintain constant the second member of equation [2].

The author considers further the influence on the degree of reaction by the variations in Q and H. The degree of reaction may be defined by either of the following equations:

$$\epsilon = \frac{p - p_e}{\triangle H} \quad \text{or} \quad \epsilon = 1 - \frac{v^2}{2gH}$$

where p is the internal pressure at the entrance to the receiver; p_e external pressure at the same point; v the absolute velocity at the same point also; kS cross section of the exit from the distributor; α angle of entrance of the stream lines into the receiver; $o = \frac{Q}{\sqrt{2gH}}$, the opening. Then:

$$\sqrt{1 - \epsilon} = \frac{o}{kS \sin \alpha} \quad \text{[3]}$$

and hence:

c In order that ϵ remain constant at all conditions of operations, $\frac{o}{kS \sin \alpha}$ must remain constant;

d If H stay constant, and section kS be reduced, the volume of flow will be reduced in proportion, and the degree of reaction ϵ remain constant;

e If H varies while kS remains constant, the volume of water is reduced in proportion to H, and ϵ is maintained constant.

The author considers three cases of varying conditions of operation, under which the speed must be maintained constant. First case: head is constant, and volume of water always sufficient to keep the turbine running at full load, the only factor likely to introduce disturbances being the variation in useful resistance. To insure the regulation of the turbine, it must be provided with a device that would keep the driving moment proportional to the moment of resistance, which may be done by maintaining H constant, and varying Q in proportion to the variation of the moment of resistance, which in its turn may be done by regulating the cross-section kS. The author shows that, as long as the gates used to reduce the section kS do not produce losses through sudden changes of cross section of kS, the mechanical efficiency is practically unaffected. The other theoretically possible method, viz., that of keeping the volume of flow constant, and varying the head, is shown to be much less convenient practically, as well as to require larger units than would be otherwise necessary.

The second case considered is where the volume of flow becomes at a certain moment insufficient to keep the turbine running at full load with the usual head. The useful output of the turbine has therefore to be reduced, the speed remaining constant. This is most often due to the variation of

level in the source of water, producing a general lowering of the hydraulic axis, and the author recommends shifting the gates so as to maintain the head H and the absolute velocity of entrance v constant, and at the same time to regulate the valves in such a manner as to change the section of entrance in proportion to the reduced magnitude of the volume of flow.

Third case: head H varies. This may be due either to accident or periodically acting causes, e. g. tides, the water level sometimes rising so high as to make the operation of the turbine impossible. As a rule, the volume of flow remains constant as long as the tide rises, or until the head water reaches the top of the weir, after which, with a further rise of water, the head water forms a supplementary resistance, and the volume of flow decreases. It is assumed here that while the head decreases, the volume of flow remains constant. With the outlet section of the distributor remaining constant, and the head, and consequently velocity v reduced, the turbine could not take care of that volume of flow, and as a result, as H decreases, Q must decrease as well, and as $Q \times H$ decrease, the output of the turbine must also rapidly decrease. Since Q decreases as $\sqrt{H}$, the output will decrease as $H^{3/2}$ while v decreases with H, which is self evident; since further w does not vary, shocks at the entrance are produced, and ρ_3 is reduced correspondingly, while ρ_1 is reduced because the constancy of speed $\xi = \frac{w}{\sqrt{2gH}}$ varies as $\sqrt{H}$. All these causes cumulatively reduce the output of the turbine with the change in available head of water, and, in order to secure the maximum of utilization of the fall, a larger unit has to be installed than is called for by the maximum volume of flow at the maximum head of water; in that case (i. e., with the turbine running with full admission at low heads, and partial admission at high heads), the output will decrease as H, and not as $H^{3/2}$ as shown above.

New Types of Centrifugal Pumps for Waterworks (*Neuere Kreiselpumpen für Wasserwerke*, Funke. *Die Fördertechnik*, vol. 6, no. 6, p. 126, June 1913, 4 pp., 10 figs., *d*). Description of some of the centrifugal water pumps built by Weise & Monski, of Halle a. S., Germany, and their characteristics. Only standard types are described.

On Water Hammer in Water Pipes Made Up of Sections of Different Diameters (*Sur les coups de bélier dans les conduites formées de sections de diamètres différents*, de Sparre, *Comptes rendus de l'Académie des Sciences*, vol. 156, no. 20, p. 1521, May 19, 1913, 2 pp., *mt*). With high water heads, pipes are often used whose diameter decreases with the increase of distance from the source of waterfall, and a consequent increase of pressure. At first sight it would appear that, should a water hammer occur, its maximum magnitude could not be beyond what it would have been if the entire conduit were made of pipe of the smallest diameter employed, i. e., at the place of maximum water velocity; the widening of the pipe in the upper part would be expected to decrease the kinetic energy of the water stored in the conduit, rather than the reverse. As the author shows, however, both of these assumptions, *for the case of sudden closure of the flow of water*, are entirely wrong. For a simple case of pipe consisting of three sections of gradually decreasing diameters, the author shows, that,

under certain elementary assumptions, the water hammer is nearly 50 per cent larger than it would have been, had the entire conduit consisted of the pipe of the smallest diameter. It appears further that in this case the water hammer occurs at the end of the sixth elementary period of oscillation, i. e., at the end of the first complete oscillation for the entire conduit. This establishes the mutual relation of the data obtained from the experiments of Allevard and the theory of Alliévi, showing why the former were in conformance with the latter only during the first oscillations. Those interested in the mathematical proof of the above are requested to communicate with the Editor.

Mechanics

Graphic Determination of Moments of Inertia and Centrifugal Moments (*Zur zeichnerischen Ermittlung der Trägheitsmomente und Zentrifugalmomente*, Professor A. Denizot, *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 26, p. 1028, 1 p., 6 figs., *t*). The process recommended

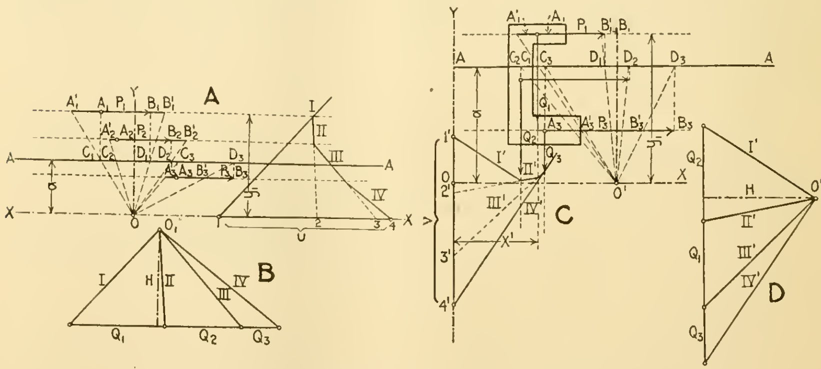


Fig. 2 Graphic Determination of Moments of Inertia

by the author is a combination of the Nehls process with the application of a funicular polygon, and may be applied to the determination of moments of inertia and of centrifugal moments in any plane section. *Moments of inertia.* Figs. 2*A* and *B*, shows the application of the process to the case of three forces, P_1, P_2, P_3, with points of application A_1, A_2, A_3 with respect to a system of rectangular coördinates OXY. The moment of inertia $J_x=P_1y^2_1+P_2y^2_2+P_3y^2_3=\Sigma Py^2$ is referred to the x axis to which the forces P are parallel. At an arbitrarily assumed distance a, a line AA parallel to XX is drawn, and the initial and final points A_1 and B_1 of the line P_1 are transformed in the same way as the points of limit of the cross-section in the Nehls process, viz., the initial and final points of P_1 are normally projected on the axis AA, to C_1 and D_1, and the points A'_1 and B'_1 determined as the points of intersection of the lines OC_1 and OD_1 respectively with A_1B_1. From the similarity of the triangles $A'_1OB'_1$ and C_1OD_1 it follows that

$$\overline{A'_1B'_1} : P_1 = y_1 : a \text{ and } P_1y_1 = \overline{A'_1B'_1}a$$

$A'_1B'_1 = Q_1$, etc., multiplied by a, give the moments of the first order of the forces P_1... To determine the moments of the second order, the line Q_1 is added to the lines Q_2 Q_3 (Fig. 2B), the apex of the polygon is arbitrarily selected, and the funicular polygon constructed; the extreme rays of the polygon I and IV cut then off on the axis XX the section u (1—4), which, multiplied by aH, gives the desired moment of inertia, which the author proceeds to prove. Should it be desired to apply this process to the case of plain sections, the latter are divided, as in the Cullmann and Mohr processes, into strips of which the center of gravity is next determined. Then through these centers of gravity or at a distance from them, parallel to the axis to which the moments are to be referred to, lines are drawn of which the length is proportional to the area of the respective strips, and proceeds as in the first case. As compared with the Cullmann process, this has the advantage of requiring no planimeter.

The centrifugal moment may be also easily determined, i.e., the expression $J_{xy} = P_1x_1y_1 + P_2x_2y_2 + P_3x_3y_3 = \Sigma Pxy$. To do this, the lines $A'_1B'_1$ .... are rotated through 90 deg. about the points $A_1(x_1y_1)$ ...., and the corresponding funicular polygon drawn, in which under certain conditions, the order of the lines Q_1, Q_2, Q_3, has to be changed. Next the funicular polygon I′, II′, III′, IV′ is constructed, and it is found that the extreme rays, I′ and IV′, cut off on the Y axis the line v (1′ to 4′), which multiplied by aH, gives J_{xy}. This is so since

$$\overline{2'3'} : \times = \frac{P_1y_1}{a} : H, \text{ or } P_1x_1y_1 = \overline{2'3'}aH,$$

hence

$$J_{xy} = \Sigma Pxy = (\overline{1'2'} + \overline{2'3'} + \overline{3'4'}) = vaH$$

Contribution to the Calculation of Shafts having Several Bearings (*Beitrag zur Berechnung mehrfach gelagerter Wellen*, H. Winkel, *Dinglers polytechnisches Journal*, vol. 328, nos. 23 and 27, pp. 353 and 424, June 7 and July 5, 1913, 7 pp. 10 figs., *mtA*). A shaft with n bearings may be considered as a continuous beam with $(n—2)$ statically undetermined conditions; i.e., in addition to the three conditions of equilibrium there are $(n—2)$ conditions of elasticity to be considered. The author states that although in civil engineering appropriate graphical processes for the calculation of continuous beams have been fully developed, these processes are described in works taking examples from fields unfamiliar to the mechanical engineer, and using scales with which he is not familiar. The present article attempts, therefore, to present the problem in a way convenient for the mechanical engineer. By starting from the Mohr formula, the author obtains the generalized form of the Clapeyron equation, from which, by means of the T-moments process, he develops a simple graphical method for the solution of the equation, for the case of a limited number of simple forces acting on the shaft. The article is not suitable for abstracting, and lack of space does not permit the complete reproduction of the mathematical treatment of the problem. For a brief discussion of single-throw crankshafts with double webs, supported on three bearings, see W. C. Unwin, *The Elements of Machine Design*, part 2, p. 173, London, 1912.

Concerning the Nomenclature of Specific Fluid Pressures (*Über die Benennung der spezifischen Flüssigkeitsdrücke*, Dr.-Ing. R. Löwy, *Die Turbine*, vol. 9, no. 16, p. 281, May 20, 1913, 6 pp., 2 figs., *g*). A criticism of the nomenclature used by the Verein deutscher Ingenieure in the Specifications for Testing Fans and Air Compressors.

Steam Engineering

Exhaust Steam and Combined Turbines (*Über Abdampf- und Zweidruckturbinen*, Dr.-Ing. K. Röder, *Elektrotechnik und Maschinenbau*, vol. 31, no. 25, p. 526, June 22, 1913, 4 pp., 8 figs., *et*). Abstract of a thesis pre-

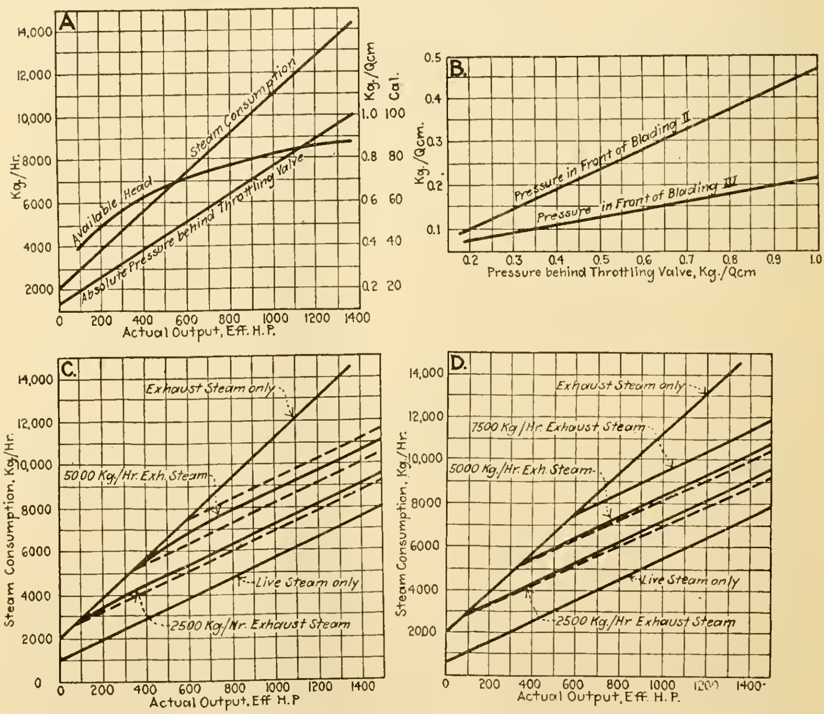


Fig. 3 Characteristic Curves of Exhaust Steam and Combined Turbines

sented by the author to the Munich Technical High School, on the subject indicated by the title of the article. Among other things investigated by the author are steam consumption of exhaust steam and combined turbines. For the latter purpose a mixed steam Melms & Pfenninger turbine, having for the exhaust steam part two multistage reaction bladings, and an impulse wheel with two velocity stages to take care of the live steam. The turbine was rated at 1000 kw., but when supplied with 14,500 kg. (31,900 lb.) exhaust steam at 1.1 atmospheres absolute, with a vacuum in the exhaust connecting branch of 92 per cent, delivered only 900 kw. The

results of the investigation are presented in diagrams, of which Fig. 3A shows the weight of entering steam and absolute steam pressure in front of the first guide blade disk as a function of the effective output; there is an increase, in a straight line law, of the quantity of steam and initial steam pressure with increase of output, and direct proportionality between quantity of steam and initial steam pressure, as well as decrease of available head with the output. This is very much like what holds good for live steam condensing turbines, but Fig. 3B, showing steam pressure in front of various bladings as a function of the pressure in front of the first guide wheel, indicates not a law of proportionality, as in the case of live steam turbines, but a straight line increase of intermediate pressures with the increase of initial pressure.

The mixed steam turbine was investigated with respect to efficiency both for throttling regulation and regulation by varying the number of open nozzle groups. The rise of the efficiency curve referred to the state behind the throttling valve, with the decrease of load is not observable

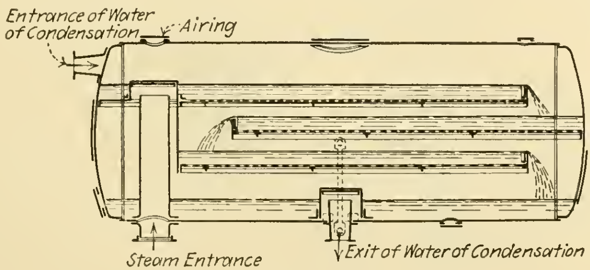


Fig. 4 Feedwater Preheater

in this case since the head in the high-pressure part varies but slightly, while the low-pressure part works even at full load with nearly the most favorable ratio of peripheral to steam velocity.

Tests for combined exhaust and live steam working have been made with both systems of regulation, their results being shown in Fig. 3C and D, the first for throttling, and the second for nozzle regulation, the exhaust steam admission in both cases being regulated by throttling. Through the points 2500 kg. (5500 lb.) and 5000 kg. (11,000 lb.) per hr., etc., of the curves (in this case straight lines) for exhaust steam operation, are drawn lines parallel to the curves of steam consumption for live steam only, and D shows that these straight lines correspond pretty well to the steam consumption curves found experimentally. These parallel lines can, therefore, be used for guarantee purposes instead of the actual steam consumption curves, thus materially simplifying the tests. In the case of throttling regulation, however, as indicated in C, this coincidence does not hold, and the actual steam consumption is larger than would be indicated by the parallel lines.

The Plant VIII/IX of the Mine Constantin the Great (*Die Schachtanlage der Zeche Constantin der Grosse*, Ilgen and Dr. Wollenweber,

(*Glückauf*, vol. 49, no. 21, p. 805, and no. 22, p. 845, 15 pp., 14 figs., *d*). Description of the mechanical equipment of the mine. In the utilization of the *waste steam* its use in the production of hot water is stated to be of greater advantage than in driving turbines. Provisions were therefore made to heat the entire feedwater up to the temperature of steam, or rather up to 100 deg. cent. (212 deg. fahr.). The apparatus shown in Fig. 4 is used, consisting of a cylindrical boiler with stepwise troughs. The feedwater enters from above, and gradually runs down through all the troughs, the steam, free from oil, entering from below and running in an opposite direction, and a special throttling valve preventing the possibility of live steam being admitted to the preheater. The hot water runs down to the feed pumps by gravity, and is used both for heating the buildings and for manufacturing purposes.

"HALL" STEAM PUMP (*Les pompes à vapeur "Hall,"* L. Béraud, *Revue industrielle*, vol. 44, no. 2087-22, p. 293, 3 pp., 7 figs., *d*). Description of

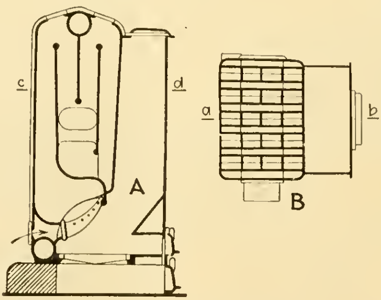


FIG. 5 BRICO SECTIONAL BOILER FOR LIGNITE BRIQUETTES

long-stroke, slow-speed, steam-driven reciprocating pumps, their valve gear and lubricating equipment. These pumps are of French construction, and have been in use for several years, mainly in France and England.

BRICO BOILER (*Der Bricokessel, Prd., Zeits. für Beleuchtungswesen*, vol. 19, no. 15, p. 195, May 30, 1913, 1 p., 3 figs., *dg*). A general discussion of the fuel problem for sectional boilers. Coke is altogether too expensive; all attempts to design an "ideal" sectional boiler that would use any fuel have failed, mainly owing to the conditions of operation of a sectional boiler, usually charged by the janitor once or twice a day, and left alone for the rest of the time. The new boiler described in this article has been designed for use with a particular fuel, lignite briquettes, and the author calls attention to the fact, that it is, like coke, an artificial fuel, and therefore more uniform in its composition and structure than native coal would be. The new boiler employs the half-gas system of heating. The fuel on the grate proper is only gasified by the primary fire, these gases being subsequently burnt immediately behind the grate with an addition of highly heated supplementary air. The author of the article states that by an ingenious system of air admission and mixing a complete combustion with a very hot flame is obtained. Fig. 5 shows the vertical and horizontal sec-

tions through the boiler. From the charging chute the fuel falls on to a grate where it is gasified. As shown in *A*, this gasification space is enclosed from above in special extensions which the author calls "air horns," the combustion chamber proper being above these extensions; the gases escape from the combustion chamber by a number of long and winding passages, and leave the plant through the rear end of the rearmost section, 3 mm (0.118 in.) draft being sufficient for normal operation. The supplementary air enters through the air extensions which are not cast in, but simply held, so that, in case of repairs, they could be easily removed. They are arranged in such manner that there is a thorough mixture between the secondary air and the fuel gases; in addition to that, soon after the furnace is started, the extensions become very hot, and preheat the air to a considerable degree.

Tests of a Brico boiler were made by the Saxony Association for the Inspection of Boilers, and have shown a utilization of fuel (lignite briquettes) of 80.98 and 83.93 per cent; the flue gases had temperatures of 182.79 and 181.71 deg. cent. (359.7 and 358.5 deg. fahr.) respectively, with contents of carbon dioxide of 13.87 and 13.12 per cent. The charging chute could take fuel for about eight hours of continuous operation, and required no attendance during that time.

Turbo-Pump Construction by C. H. Jaeger & Co., H. Mitter (*Zeits. des Vereines deutscher Ingenieure*, vol. 57, nos. 26 and 27, pp. 1005 and 1052, 18 pp., 72 figs. *d*). Description of the various types of centrifugal water pumps built by C. H. Jaeger & Co. Table 1 giving test data is of interest.

Efficiencies of 75 and 78 per cent have been reached, these representing, according to the author, the highest efficiencies obtained with pumps of those sizes. They are below the highest efficiencies attained with new reciprocating pumps of the best design, which, however, does not prove that reciprocating pumps are more advantageous. They are affected by the kind of water they handle in a higher degree than centrifugal pumps, and are more subject to loss of efficiency through having handled dirty water than centrifugal pumps of good design. The latter, in addition, require as a rule very little repairs, and the author quotes a case when a centrifugal pump after seven months' continuous work in a mine cost less than two dollars in repairs (caused by replacing a stuffing box packing). He points out further that in pump operation power costs are not inversely proportional to the efficiency of the pump, this being due to the fact that the high-speed electric motor is more economical than the slower speed motor required to drive a reciprocating pump. The saving in space, easier starting and higher reliability of the centrifugal pumps are also important factors in its favor.

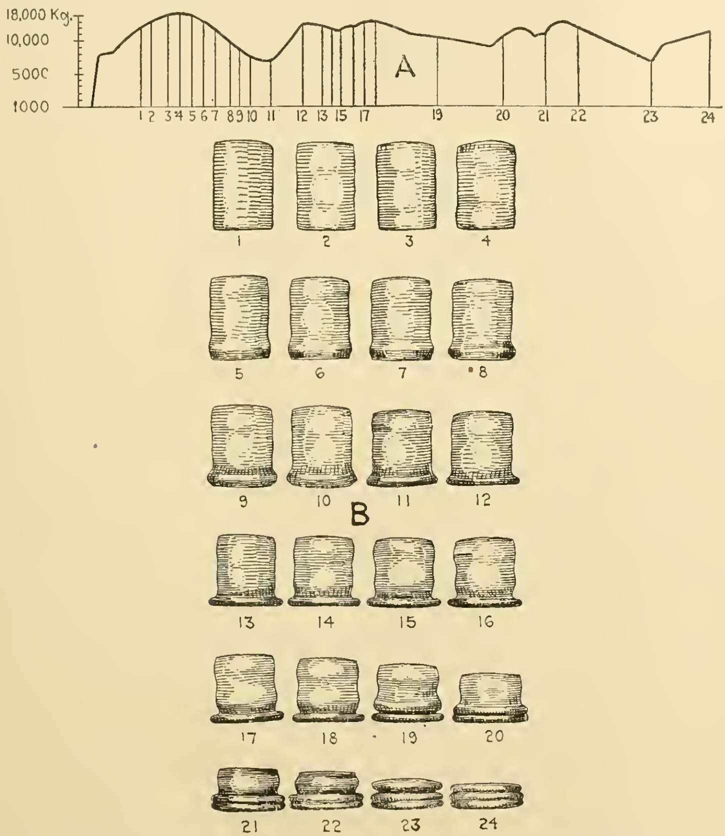
Strength of Materials and Materials of Construction

Distribution of Deformations in Stressed Metal (*Distribution des déformations dans les métaux soumis à des efforts*, Ch. Frémont, *La Technique moderne*, vol. 6, no. 11, p. 401, 4 pp., 35 figs., *eA*). The author discusses the phenomenon of wrinkling of metal tubes subjected to compression. He calls attention to the well-known cases of formation in tubes

TABLE 1 DATA OF TESTS OF C. H. JAEGER & COMPANY'S CENTRIFUGAL PUMPS

Name of Plant	Mine König Ludwig	Mine Prussia II	Mine Hansa	Mine Augusta Victoria	Mine Queen Elisabeth	Mine Zollern
R.p.m.	1440	1475	1495	1470	1475	1475
Power supplied to motor, kw.	436.8	682.68	785.5	651.0	350.4	515
Efficiency of motor, per cent	94.0	94.0	95.0	94.0	93.5	95.0
Power delivered to pump, h.p.	557.9	871.8	1015.0	831.3	445	665
Total manometric head, m.	557.7	612.24	755.5	768.4	412.3	407
ft.	1829.25	2008.0	2478	2520	1352	1334
Volume of water, cbm/min.	3.41	4.97	4.63	3.78	3.65	5.66
cb.ft./min.	120.3	175.4	163.4	133.4	128.8	129.1
Output of pump in water lifted, h.p.	423	676.7	776.3	645	334.17	511
Total efficiency of plant (pump and motor) referred to the manometric head, per cent	71.2	73.0	72.7	72.9	70.2	73.0
Efficiency of pump referred to the manometric head, per cent	75.7	77.5	76.4	77.5	75.1	76.8
Guaranteed pump efficiency, per cent	72	73	72	70	72	....

compressed to the points of collapse, of regular concentric folds, and attempts to explain it from data obtained in his own experiments. After a series of tests with tubes of various thickness and materials, the author prepared 24 steel tubes, 50 mm (1.96 in.) in diameter, 80 mm (3.14 in.) long, with walls 2.5 mm (0.1 in.) thick, and completely crushed one of these specimen tubes, taking at the same time a record of the work of compression. In the tube were formed three concentric folds (Fig. 6*B*, 24), while

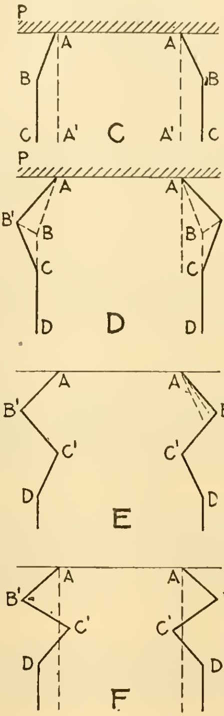


FIGS. 6*A* AND 6*B* DEFORMATION OF METAL TUBES UNDER COMPRESSION

the diagram of work looked as shown in Fig. 6*A*. The other 23 specimens were treated like the first, with the difference, however, that in each test the process of compression has been stopped at a different point, as shown by the respective numbers on the work of the compression diagram. The shapes of the tubes after compression are shown on Fig. 6*B*. In all these compression tests no guide frames or mandrels were used.

The author explains in the following manner the striking regularity of the circular folds formed on the tube by axial compression. Under the action of compression, the end of the tube changes its shape, at first elasti-

cally, and then permanently, the generating lines being forshortened, and the diameter tending to increase. Since, however, the ends of the tubes are kept in place by their friction against the plates of the press, the increase in diameter is not uniform throughout, and, as a result, a tendency is produced towards the formation at the ends of the tube of truncated cones. Fig. 6*C* shows the beginning of the formation of such a cone. The tube, of initial diameter AA', under compression, spreads out, and its diameter, at a certain distance from the plate of the press P, increases to BB, while



Figs. 6*C*, 6*D*, 6*E* and 6*F* Deformation of Metal Tubes under Compression

the friction at P keeps there the original diameter AA' unvaried. During the change of shape of the tube, the direction of pressure is no longer on lines parallel to the longitudinal axis of the tube, but along the inclined line AB, the generating line of the truncated cone. With the pressure continued, the height of the cone decreases, not because the generating lines foreshorten, however, but because they incline more than before; the diameter of BB increases still more, and finally becomes $B'B'$, and the inclined direction of the stress produces in the originally cylindrical parts BC, a corresponding deformation to $B'C$ (strictly speaking, BC ceases to be cylindrical from the moment of the diameter of BB departing from its original magnitude AA'.—Editor). After the two opposite truncated cones shown in Fig. 6*D* have been formed, the pressure continuing in the direction of

the generating lines, the trunks of the cones decrease in height, the common bases $B'B'$ expand, and assume the form of a circular fold (Cp. Fig. 6*B*, 7 to 13). The base AA' subject to friction againsr the press plate, cannot change its shape, but the base CC of the other cone can do so more easily and, accordingly, the pressure acting all the time along the generating lines tends to push *towards the interior* of the tube the third section of the tube $C'D$, which becomes also a truncated cone first, and part of a second circular fold later (Cp. Fig. 6*E* and *F*, and in *B*, nos. 15 to 20). The deformation is therefore due to compression initially, and to bending later on. The author shows that all deviations from the process described are due to accidental causes, such as the shape of the pipe, irregularities in the constitution of the material, etc.

A New Chemical Cause of the Rusting of Iron (*Eine neue chemische Ursache des Rostens von Eisen*, Dr. W. Vaubel, *Chemiker-Zeitung*, vol. 37, no. 69, p. 693, June 10, 1913, 1 p., *t*). The author draws attention to the important part of *nitrous compounds*, in particular, *ammonium nitrate*, in the production of *rusting of iron*. He further shows not only that ammonium nitrate is widely present in ground waters, but that it may be formed from the nitrous compounds in the air through the intermediate action of oxides and hydroxides of iron.

A New Process for Detecting Cracks, Untight Places and Slag Inclusions in Autogenously Welded Pieces (*Ein neues Verfahren, um Risse, undichte Stellen und Schlackeneingüsse in autogen geschweissten Stücken nachzuweisen*, A. Stadler, *Die Turbine*, vol. 9, no. 18, p. 324, June 20, 1913, 1 p., 1 fig., *pd*). The author recommends, for detecting defects in autogenously welded pieces, the use of an etching solution consisting of 100 parts (by weight) of water, 5 parts of chemically pure nitric acid, and 5 parts of potassium chlorate. The burnt iron is shown by an increase in the size of crystals and their dark color; cracks appear as dark lines. Slag inclusions are not affected by the etching solution, and come out prominently through their glassy appearance. The etching solution gives the metal a light gray color, on which all irregularities come out very well.

Compression Tests of Vulcanized Fiber, Hard Rubber and Metal for Stuffing Box Packing at Ordinary and Higher Temperatures (*Druckversuche mit Vulkanfiber, Hartgummi und Metal für Stopfbüchsenpackungen bei gewöhnlicher und höherer Temperatur*, R. Baumann, *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 23, p. 907, June 7, 1913, 4 pp., 12 figs., *e*). Data of tests made at the Laboratory for Testing Materials at the Royal Technical High School, Stuttgart, Germany. It has been found that the compressive strength of all the above materials rapidly decreases with the increase in temperature. The temperature at which a material is tested for its compressive strength ought, therefore, to be indicated. When vulcanized fiber takes up moisture, it rapidly expands, but not uniformly in all directions. Its hardness and compressive strength depend also materially on the direction in which the stress is applied. Hard rubber, when under greater stresses, is apt to flow, with a tendency towards the formation of cracks, simultaneous with an increase in cross-section. By "metal" the author means an alloy of lead and antimony, with about 30 per cent of the latter.

NECROLOGY

WILLIAM M. DOUGLASS

William M. Douglass, treasurer of the Globe Real Estate Company of Allentown, Pa., died in that city on March 23, 1913. Mr. Douglass, who was one of the early members of the Society, began his professional career in 1878 in the steel mill of the Gautier Steel Company, Johnstown, Pa., where he had partial charge of erecting engines and trains. In the following year he was given the management of the mill and during the subsequent years of his connection with it built one train and rebuilt two others, mainly from his own plans. In 1883 he began the plans for the Hartman Steel Company at Beaver Falls, erecting all the roll trains, engines, boilers, etc., partly from his own designs. In September of the same year he was made superintendent of the entire plant.

In 1884 Mr. Douglass removed to Allentown, to become general superintendent of the Iowa Barb Wire Company, continuing in this capacity until 1894 when he became general superintendent of the Consolidated Steel & Wire Company. In 1899 he became superintendent of the American Steel & Wire Company of the city, advancing in 1904 to the position of assistant to the general superintendent. He retired from the rolling mill field in 1906, and in 1911 entered the business in which he was engaged at the time of his death.

SAMUEL LYON MOYER

Samuel Lyon Moyer, first vice-president of The Lunkenheimer Company of Cincinnati, Ohio, died at his home in that city on May 3, 1913. Mr. Moyer was born in Cincinnati on August 17, 1874, and was educated in the public schools. He had been connected with the company since 1890, almost from the time of the completion of his school work, working his way up to the management from a small beginning, entirely by his industry and rare ability.

He was a deep student of men and affairs, possessing clear

vision and remarkable foresight, and contributed at every opportunity of his time, money and intellect for the growth and advancement of his native city. While not an active engineer he was well informed and keenly interested in engineering and scientific tests of the day, particularly in the line of progress and development.

Mr. Moyer was a member of the National Metal Trades Association, and a number of social and business clubs.

JOHN BRADFORD PERKINS

John Bradford Perkins was born in Boston, August 2, 1869. He was educated in the public schools of Lowell, Mass., and served an apprenticeship with the General Electric Company of Lynn, Mass., and the Lowell Machine Company of Lowell. Upon its completion he entered the employ of Hollingsworth & Vose, at Walpole, Mass., resigning to enter the Crosby Steam Gage & Valve Company. In 1905 he became the New England manager for the Hewes & Phillips Iron Works, Newark, N. J., manufacturers of Corliss engines. The John B. Perkins Company, a firm which engaged in the installation of complete power plants, was organized by him the following year, Mr. Perkins serving as its president up to the time of his death on January 19, 1913. In this capacity he made many important installations, notably the Fitchburg Yarn Company, with its record for economical operations, the Windham Manufacturing Company, Willimantic, Conn., the Burgess Mills, Pawtucket, R. I., and the Potomsko Mills, Fall River, Mass. He also designed and put on the market the "Bradford" valves.

Mr. Perkins was a member of the Engineers' Club of Boston, the New England Street Railway Club, the National Association of Stationary Engineers, the Nayassett Club of Springfield, the Quequechan Club of Fall River, and the Deerfield Club of Manchester, Vt.

FRANCIS M. RITES

Francis M. Rites was born at Petersburg, Ill., on July 20, 1858, and received his preparatory education at Chester, N. Y. He entered Sibley College, Cornell, in 1877, graduating with the degree of B.M.E. in 1881.

Directly after leaving college, he entered the employ of the Lehigh & Hudson River Railroad for a short time, and in 1883 became identified with the Westinghouse Machine Company,

During his connection with them he made many notable developments and inventions, among them a system of high-speed compressors, a new system of explosive engine control and distribution, and the inertia governor, for which he is best known. He died at his home in Slaterville, N. Y., on May 2, 1913.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

Address of C. C. Chamberlain to the Special Committee of the German Reichstag (in English and German). Gift of author.

American Railway Association. Proceedings of session held in New York City, May 21, 1913. Gift of association.

Association of Railway Electrical Engineers. Proceedings. vols 1-4. *Chicago, 1908-1911.* Gift of association.

Beiträge zur Geschichte der Technik und Industrie, herausgegeben von Conrad Matschoss. Vols 2 and 3. *Berlin, 1910, 1911.*

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Columbia University, Ernest Kempton Adams Fund for Physical Research. Publication nos. 4 and 6. *New York, 1912.* Gift of the university.

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Engineering Tables and Data, W. W. F. Pullen. ed. 3. *Manchester, England.*

A useful compilation, which, although containing only 68 pages, gives much information which engineers need. The steam table has been thoroughly revised, and represents the result of the most recent researches.

Les Etats-Unis d'Amérique, D'Estournelles de Constant. *Paris, 1913.* Gift of American Association for International Conciliation.

Experiments in the Preservative Treatment of Red-Oak and Hard Maple Crossties, F. M. Bond. U. S. Dept. of Agriculture, Forest Service Bull. 126. *Washington, 1913.* Gift of author.

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Handbook of Natural Gas, Henry P. Westcott. *Erie, 1913.*

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Jerome Park Filters, Report of the Advisory Commission of Engineers. Part I: Relating to Filtration of Croton Water. Gift of N. S. Hill, Jr.

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Die neueren Methoden der Festigkeitslehre und der Statik der Baukonstruktionen, Heinrich Müller-Breslau. ed. 4. *Leipzig, 1913.*

New York State Engineer and Surveyor. Annual Report, 1912. *Albany, 1913.* Gift of State Engineer and Surveyor.

New York State Library. Handbook for readers concerning the New York State Library and its home in the State Educational Building. *Albany, 1913.* Gift of the department.

Oerlikon Lötschberg Electric Locomotive, no. 121, 2000 B.H.P. Reprinted from "The Engineer," February 2, 9, 1912. Gift of Maschinenfabrik Oerlikon, Zürich.

Ohio Electric Light Association. Proceedings of the 17th Annual Convention. *1911.*

Pavement Guarantees, Their Use and Abuse, J. W. Howard. *New York.* Gift of author.

Pennsylvania Society Year Book, 1910. *New York, 1910.*

Petrol Air Gas, the New Form of Illuminant, C. A. M. Smith. *London.*

Practical Alternating Currents and Alternating Current Testing, C. F. Smith. ed. 5. *Manchester, England.*

That a textbook for college students has reached a fifth edition is a guarantee that it is well liked and well adapted to its purpose.

Progress Report on Wood-Paving Experiments in Minneapolis, F. M. Bond. U. S. Dept. of Agriculture, Forestry Service, circular 194. *Washington, 1912.* Gift of the author.

Scientific Salesmanship, C. H. Pierce. *New York, 1906.*

Service and Meter Installation Rules, New York Edison Company, June 1913. *New York, 1913.* Gift of C. W. Rice.

Some Tests to Determine the Effect upon Absorption and Penetration of Mixing Tar with Creosote, F. M. Bond. Gift of the author.

STEAM POWER PLANT ENGINEERING, G. F. Gebhardt. ed. 4. *New York, 1913.*

This edition has been largely rewritten and many illustrations added. There are particularly full data on power costs.

SWEDISH ENGINEERS' SOCIETY OF CHICAGO. Constitution and By-Laws and List of Members, 1913. Gift of the society.

TECHNOGRAPH. vol. 13, 16. *Urbana, 1899, 1902.* Gift of University of Illinois.

UNIVERSITY OF CHATTANOOGA. Catalogue 1907-1908, 1911-1912, 1912-1913. *Chattanooga.*

EXCHANGES

ECOLE D'APPLICATION DU GÉNIE MARITIME. COURS DE MACHINES À VAPEUR. vol. 3. *Paris, 1912.*

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———Proceedings 1912, pt. 3-4. *London, 1913.*

TRADE CATALOGUES

FAIRBANKS COMPANY, *New York, N. Y.* Catalog B 30, Makutchan roller bearings and hangers, 31 pp.

GOLDSCHMIDT THERMIT COMPANY, *New York, N. Y.* Thermit marine repairs, 1913.

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RAILWAY CAR DOOR COMPANY, *Chicago, Ill.* Reasons why freight car doors should be placed inside of the car instead of outside, 7 pp.

UNITED ENGINEERING SOCIETY

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Year Book 1912. *Washington, 1913.* Gift of the endowment.

NEBRASKA STATE RAILWAY COMMISSION. 5th Annual Report. *Lincoln, 1912.* Gift of the commission.

PATENTE JAHRES-KATALOG, 24th year 1912. *Brugg, 1913.*

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

506 Superintendent of large experience in automobile and Diesel engine construction. Location Middle West.

608 Technical graduate with one or two years' experience, wanted as instructor in mechanical engineering. Location Western Pennsylvania.

702 Technical expert wanted in purchasing department of a large works near New York, making high-grade light metal products, to assist in selecting, buying and inspecting the varied materials used. Should be good metallurgist, fair chemist and familiar with fuels. Apply through the Society, giving age, education, experience, reference and approximate salary required.

703 Wanted by Ohio concern, mechanical draftsman experienced in the design of large steam or gas engines. State experience and salary expected. Apply through the Society.

704 Engineer, capable of taking charge of general construction work around various plants, looking after construction of new buildings, remodeling, mapping out changes, betterments for power, fuel, crude oil and producer gas furnaces, installation of new machinery, rearranging old machinery to effect economies, etc. Location Middle West.

705 Instructor to handle first year mechanical drawing work and to teach civil engineering subjects; if possible one who has had practical experience and contact with affairs along structural engineering lines, as well as a year's teaching experience. College or technical school graduate with initiative. Location Philadelphia. Salary about $1200.

706 Partner to assist in development of a new steam turbine, of the compound impulse multi-stage type, capable of good efficiency in all sizes from 1 h.p. upward, and now ready for commercial development. A high-grade successful salesman of steam turbines desired who can furnish necessary capital.

707 A large manufacturing company located within fifty miles of New York, seeks the services of an experienced mechanical and electrical engineer. Position is technical rather than administrative. Duties: to study the plant, equipment, processes and products, to report those found defective, inefficient or wasteful, and to make recommendation for increasing the economy and efficiency of production, and improving the quality of the product which comprises a wide

range of metallic articles. Apply through the Society, stating age, training, experience, references and salary expected.

708 Wanted foundry superintendent; thoroughly high-class man able to take entire charge of foundry employing about 140 men on high-grade machine tool work. Must thoroughly understand modern methods of molding with machines, the mixing of irons and be an executive of highest order. Foundry is equipped with the most modern appliances and is comparatively new. Only a man of high ability desired, technical graduate preferred. Apply through the Society. Location Middle West.

709 Partner desired by consulting and advisory engineer, engaged principally along lines of mechanical refrigeration, cold storage and ice-making plants. Experience in the ice-machinery line immaterial, but some investment in the business expected.

712 Experienced heating and ventilating engineer for New York concern. Apply through the Society.

714 Editor, aggressive, energetic young man of technical training, familiar with publishing business. Salary from $25 to $40 a week depending upon experience. Location New York.

716 Mechanical draftsman, Sandy Hook Proving Ground, $100 per month. One capable of filling position temporarily until an eligible can be supplied by the U. S. Civil Service Commission. Applicant should have a good mechanical education and at least two years' practical drafting experience. Replies should state fully both training, experience and age. Examination will be held on August 6, in New York City, for the purpose of filling this position permanently.

718 Teaching position open with large eastern engineering school. A mechanical engineering graduate wanted, preferably with some experience in practical work. Appointment will be made early in September. Apply through Society.

719 Young engineer on sales work. Location at first in New York City at $15 to $20 per week. Later upon making good to go to Havana.

720 A well-known manufacturer of high-grade steam specialties wants manager for long established branch office. Must have thorough knowledge of power plant equipment and be a salesman of tried and proven ability. Complete history of previous work and references that will stand rigid investigation are necessary. Apply through Society.

MEN AVAILABLE

175 Junior member, 30 years of age, at present employed, technical education, 10 years' experience in design, construction, operation, maintenance and reorganization of mill, factory, and other manufacturing properties. Wide experience in the superintendance of central power stations, factory extension, mill and reinforced-concrete construction work.

176 Aggressive, broad gage man with initiative, exceptional ability, acquired by wide experience in mechanical and electrical manufacturing and sales, energy and tact. Now sales manager; has worked from drafting room to superintendent in bronze, iron and steel foundry and machine shop; desires to connect with reputable concern where first-class man will have opportunity to produce maximum results. Familiar with government business and requirements. Age 36.

177 Technical graduate, Junior member, age 30, eight years' experience in designing, estimating costs, construction and inspecting in car and locomotive work, contractors' equipment, heating and ventilating. In charge of men and competent to manage field and office operations. Now open for position as branch manager, engineer-in-charge, or salesman. Personal interview desired. Clean references from previous connections.

178 Student member, age 27, graduate Cornell 1913, seven years' experience as machinist (prior to and during summers of college course), wishes to locate in the East or South.

179 Superintendent or chief engineer, graduate in mechanical and electrical engineering degree of M.E. and two years in naval architecture at M. I. T. Experienced as designer, superintendent of shop and erecting. Familiar with latest practice in machine shop and shop construction, and scientific management of men in factories. Desires position with opportunity to advance.

180 Member, technical graduate, B.S. and M.E., at present employed, desires to make a change. Experience in power plants, pipe and electrical lines, lighting, heating and ventilation. Familiar with design, preparation of plans and specifications, supervision of construction, and operation after completion. Salary $200 to $250 per month, depending on location, opportunity, etc.

181 Member with broad varied experience in manufacturing lines desires to make a new connection September 1, preferably with a medium sized plant, to look after the manufacturing end. Can invest a small amount of capital if desired.

182 Mechanical engineer, age 29, with liberal experience in the design, construction and operation of power plants, industrial plants and conveying and transmission machinery, good organizer and executive, capable of handling efficiently large numbers of men, wants position as principal or assistant engineer on the construction of plant, or with consulting engineer, or as plant superintendent or assistant with manufacturing concern. Location no object, but Middle or Far West preferred.

183 Junior member, age 27, technical graduate in mechanical engineering, experienced in detailing and estimating on steel plate work, wishes to secure position in the estimating and sales department of a company doing plate and boiler work.

184 Construction superintendent, desires position with some future possibilities. Thirteen years' practical experience in construction work, design and operation of power stations, power distribution, general construction work, structural steel, reinforced concrete; expert in steam handling; holds first-class engineers' license for Massachusetts. Accustomed to handling men, purchase of material and equipment, and office work. Can give best references.

185 Member desires change of position with opportunity to make full use of engineering training and practical experience. Thoroughly familiar with all machine shop operations and practices, designing, various lines of mechanical products and the tools for their interchangeable manufacture. Assistant superintendent or in engineering capacity.

186 Graduate mechanical engineer, age 36, desires permanent position in or near New York. Excellent experience in engineering, purchasing and sales work

with consulting, manufacturing and selling concerns. At present employed in executive sales position, but desires to change for better and more permanent work.

187 Junior member, age 27, at present with large Eastern concern manufacturing a general line of brass goods, as designing engineer on tools, fixtures, special automatic and pneumatic machinery, experienced tool maker and machinist, desires position with manufacturing concern in Connecticut, as designing engineer or master mechanic.

188 Mechanical engineer with practical machine shop experience, technical education, three years' experience in elevating, conveying, mine and power transmission machinery, desires position as sales engineer with firm or representative located in Pittsburgh.

189 Superintendent or works manager; fifteen years' experience in the manufacture of light and heavy engines, machine tools and various lines of merchandise, and connected with the factory division of a very large mail order house for the past two years. Has had broad experience in establishing and maintenance of premium and piece work plan of wage payment.

190 Executive engineer, member, age 37, seventeen years' broad and diversified experience in engineering, organization and general business, at present manager of large industrial plant, will consider new connection with a big proposition requiring both executive and engineering ability.

191 Junior, age 30, single, with technical training and experience in design and construction of high voltage transmission lines and substations, also experienced in hydrograph computations, would like to make connections with large firm doing hydroelectric work. Salary according to requirements of position.

192 Sales engineer desires position where a knowledge of machinery and mill supply trade in United States and Canada is essential; seven years' varied engineering experience, nine years in selling end. Experience in correspondence and design of selling contracts.

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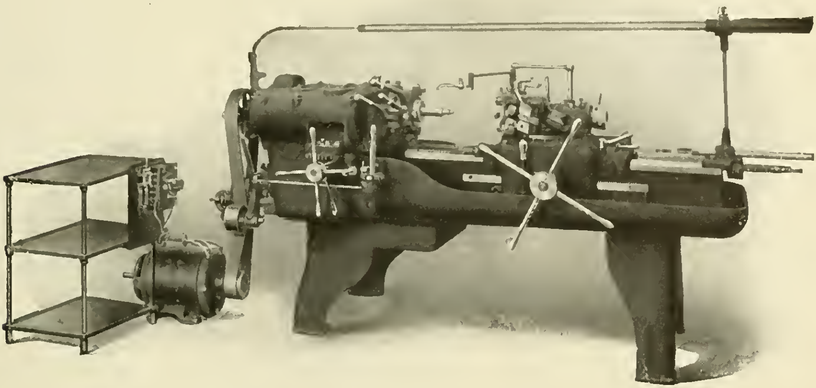

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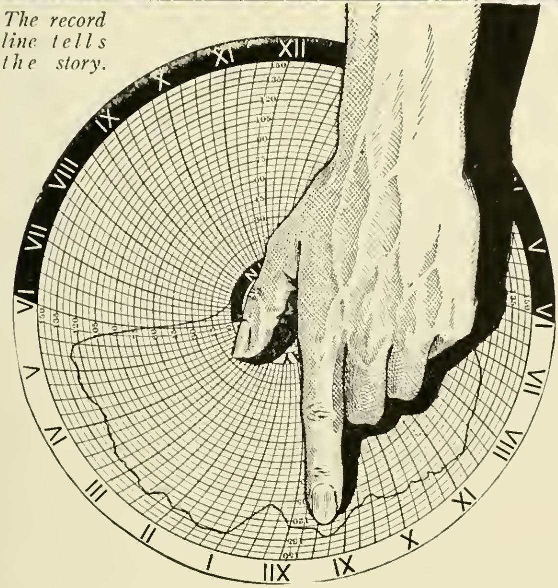

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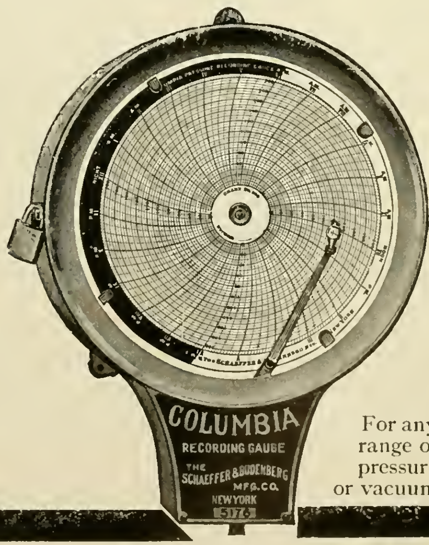

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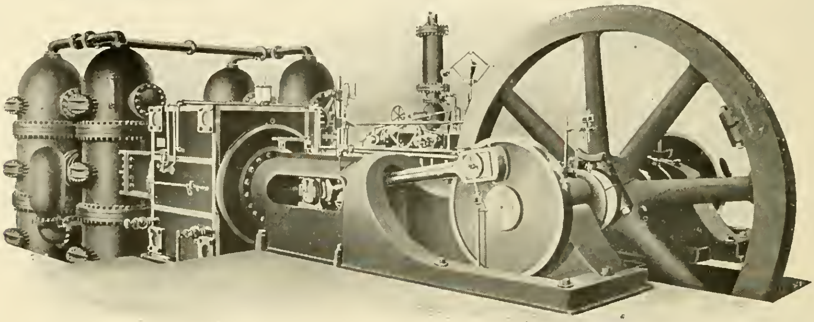

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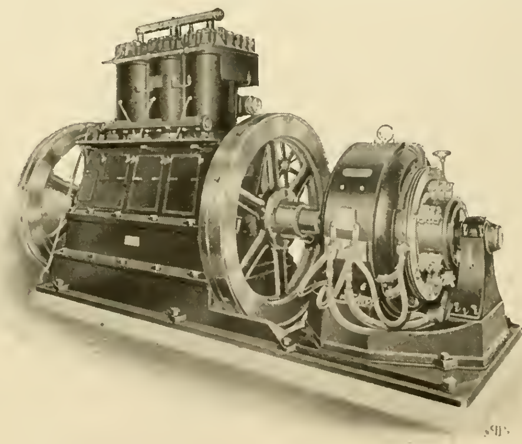

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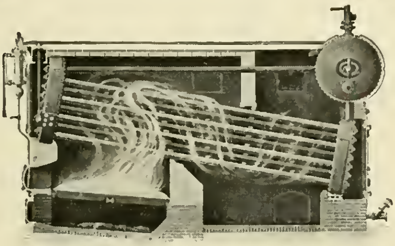

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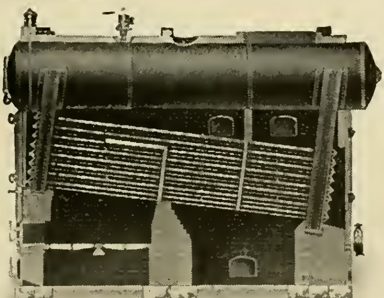

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Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

ROBINS BELT CONVEYORS

ROBINS CONVEYING BELT COMPANY

13 Park Row, New York

The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

WIRE ROPE

JOHN A. ROEBLING'S SONS COMPANY

TRENTON, N. J.

Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

CRANES
MONO-RAIL SYSTEMS
CON-TROLLERS

SHAW ELECTRIC CRANE CO.

MUSKEGON, MICH.

Electric Travelers for all purposes. Gantries. Wharf Cranes. Railroad Wrecking Cranes. Mono-Rail Systems. Electric Motor Controllers.

CRANES
HOISTS

THE TOLEDO BRIDGE & CRANE CO.

TOLEDO, OHIO

Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

AIR COMPRESSORS AND PNEUMATIC TOOLS

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POWER TRANSMISSION

ENGINEERING MISCELLANY

CONDENSED CATALOGUES

OF

MECHANICAL EQUIPMENT

POWER TRANSMISSION MACHINERY

HOISTING, ELEVATING AND CONVEYING MACHINERY

INDUSTRIAL RAILWAY EQUIPMENT

Other sections of the Condensed Catalogues to be published in subsequent issues of The Journal during 1913 will include Metal Working Machinery, Machine Shop and Foundry Equipment, Steel Works and Rolling Mill Equipment, Pumping and Hydraulic Machinery, Electrical Equipment, Mining and Metallurgical Equipment, Heating and Ventilating Apparatus, Refrigerating Machinery, Air Compressors and Pneumatic Tools, and Engineering Miscellany.

At the close of the year the entire collection of Condensed Catalogues will be reprinted in volume form.

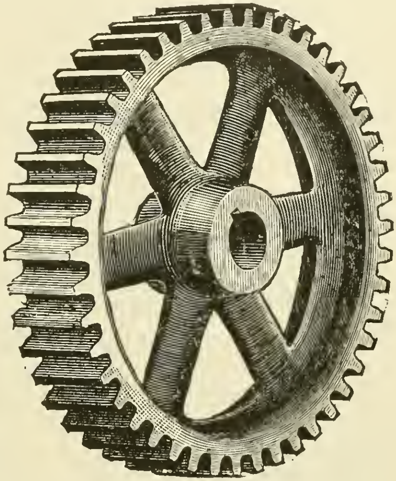
THE AMERICAN SOCIETY *of*
MECHANICAL ENGINEERS

THE A. & F. BROWN CO.

79 Barclay Street, NEW YORK CITY

Works: ELIZABETHPORT, N. J.

ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS. MANUFACTURERS OF GEARS OF ALL DESCRIPTIONS, TURNED STEEL SHAFTING, PULLEYS, SPLIT PULLEYS, FRICTION CLUTCHES, SPECIAL MACHINERY, ETC.



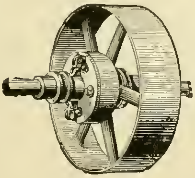
CUT GEARS

These gears are cut on the best up-to-date automatic machines obtainable, enabling this department of the shops to turn out accurately cut gears of every description and size.

MACHINE MOULDED GEARS

The Gear Department of our foundry is fitted up with the most modern gear moulding machines, enabling us to furnish machine moulded gears up to 16 feet diameter, and 25 tons in weight if in one piece, and heavier if split, or built up. These gears are much more accurate than ordinary cast gears and are of the toughest mixture of iron.

FRICTION CLUTCHES



The F. Brown Friction Clutch is simple, compact and having few small parts is not liable to get out of order; engages gradually and when thrown "in gear" has a stronger grip than any other, owing to the large friction surfaces and powerful operating device which is a combination of double ended (or right and left thread) screw and toggle joint.

SIRENS

These fog signals are used by the United States Navy and Light-house Departments, also by a number of foreign governments and many steamships. They are also in use as fire alarm signals in small towns and large manufacturing plants.

COGSWELL MILL

The problem of grinding or pulverizing many materials has been successfully solved by this machine.

SPECIAL MACHINERY

These shops are particularly well equipped for building special machinery to plans and specifications. The pattern shop, foundry and machine shops are strictly up-to-date in all particulars and equally well equipped to turn out work of the heaviest character as well as light machinery requiring first class material and workmanship and most modern tools.

Established 1854. Incorporated 1898.

THE FALK COMPANY

MILWAUKEE, WISCONSIN

MANUFACTURERS OF PRECISION HERRINGBONE GEARS WITH STAGGERED TEETH (WUEST PATENTS)

WUEST HERRINGBONE GEARS

We manufacture a complete interchangeable system of herringbone gears, with teeth generated on special machines, designed and built exclusively for our own use.

The gears which we produce are hobbed, both sides at once, in solid blanks.

A Large High Ratio Gear for a Mine Hoist

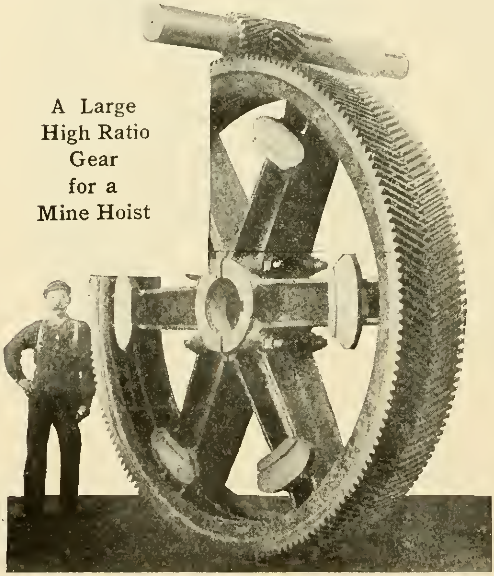


Fig. 1

The Wuest System of staggered teeth, besides giving the maximum contact surface for a given width of face, is invaluable in securing unbroken continuity of engagement when using high ratio pinions with very few teeth.

Other distinctive features:—

- Highest attainable accuracy.
- Involute tooth form on *circumferential* section.
- Invariable spiral angle.
- Perfect interchangeability.
- Equal efficiency in both directions.

Wuest herringbone gears transmit power by smooth, continuous action without jar, shock or vibration.

They are almost noiseless.

They can be used for extremely high *single* gear ratios. In this connection we make a specialty of forged pinions in one piece with their shafts. Ratios of 15 to 1 are quite normal and 20 to 1 may be used when necessary. Wuest gears can be run with safety at far higher velocities than the spur type. Special gears for use in connection with steam turbines are suitable for speeds up to 7000 feet per minute.

Referring to illustrations, Fig. 1 shows a large high ratio gear for mine hoist. Fig. 2 shows an application of high ratio gears for a large vertical triplex pump. Fig. 3 is a standard turbine gear unit forced lubrication type.

THE FALK COMPANY

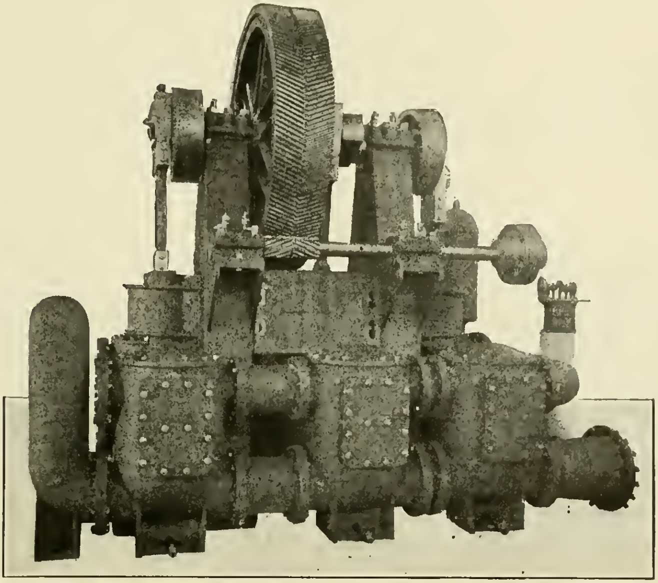


Fig. 2

SPECIAL ADVANTAGES

Long life.

High efficiency (loss never exceeds 1% at rated load).

Elimination of countershafts and double-gear trains.

Absence of vibration with prevention of shaft crystallization and breakdown of motor insulation.

Quiet action with durable steel pinions.

The range of application for Wuest herringbone gears covers every case where spur gears are used and many new fields where spur gears are impossible.

Specially adapted for

Marine Steam Turbines.
Turbo-Generators.
Turbine-driven centrifugal pumps, mills and shafting.
Rolling Mills and Rod Mills.
Tube Mills and Crushing Plant.
Power Pumps.
Air Compressors and Blowers.
Hoisting, Elevating and Conveying Plant.
Rubber Machinery.
Machine Tools.

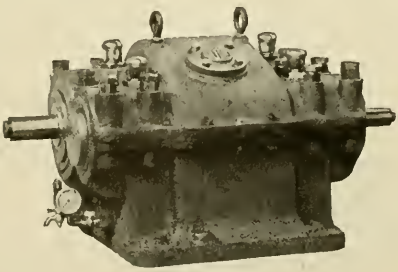


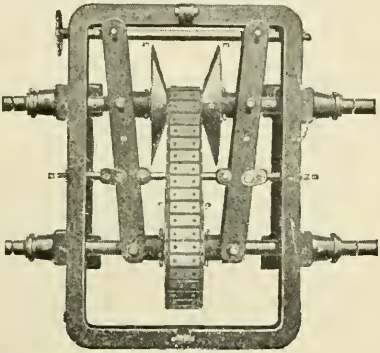
Fig. 3

REEVES PULLEY COMPANY

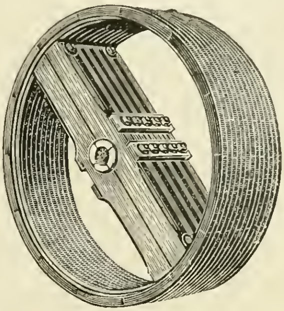
COLUMBUS, IND.

Branch House: Clinton and Monroe Sts., Chicago

"THE REEVES" PATENT VARIABLE SPEED TRANSMISSION, PATENT WOOD-SPLIT PULLEYS, PATENT WOOD-SPLIT PULLEY CLUTCH; POWER TRANSMISSION APPLIANCES



"The Reeves"
Variable Speed Transmission



"The Reeves"
Wood-Split Pulley

"THE REEVES" VARIABLE SPEED TRANSMISSION

Construction and Operation. The essential feature is that two pairs of cone disks are spline mounted on two parallel shafts. These disks are operated by a pivoted bar which is operated by a screw in such manner that one pair of disks is brought together while the other pair is forced an equal distance apart. At the same time a uniform tension of the special belt is maintained. Efficiency from 80% to 95%, according to conditions of the service.

The inner sides or faces of the disks form a V-shaped groove into which is fitted an especially designed belt, having its bearing surface on the edges instead of the bottom, as with an ordinary belt.

One set of disks acts as driver and the other driven. As the disks are actuated so the belt assumes the large diameter on one pair of disks, it at the same time assumes the small diameter on the opposite pair, thus increasing or diminishing the speed of the driven shaft, and giving any speed between the two extremes of variation.

Installation. "The Reeves" Variable Speed Transmission is installed in the same manner as an ordinary countershaft and may be placed on the floor or suspended from the ceiling as desired.

Application. It may be applied to any machine or mechanical device whatever requiring variable speed, such as Iron Working Tools, Canning Machinery, Packing Machinery, Bakers' Machinery, Laundry Machines, Textile Machinery, Veneer Cutters, Dryers, Cement Machinery, Paper Making Machinery, etc.

Sizes. Made in sizes from 2 H.P. to 150 H.P. Speed Variation as great as ten to one, or less as required.

Catalogue on request.

"THE REEVES" WOOD-SPLIT PULLEY

"The Reeves" Wood-Split Pulleys are made in all sizes up to 30 ft. diameter. Being fitted with interchangeable bushings they may be changed from one shaft to another of different size at an expense of a few cents for a new bushing.

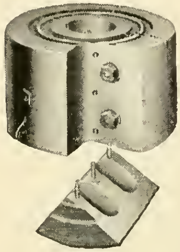
Stocks carried in all jobbing centers.

Catalogue on request.

SAGINAW MANUFACTURING COMPANY

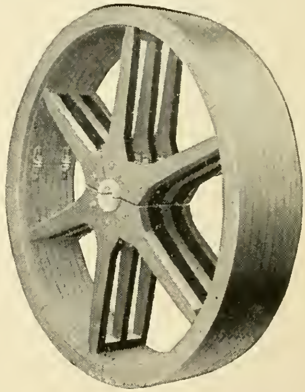
SAGINAW, MICH.

MANUFACTURERS OF THE GILBERT WOOD SPLIT PULLEYS



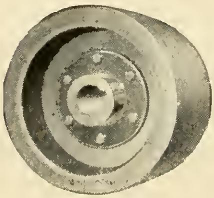
STYLE C PULLEY

All of our pulleys are made of thoroughly seasoned maple, and finished with two coats of varnish. Pulleys of this style are bolted together—the nuts on the clamping bolts being covered with sectional blocks which cannot get out of place and, when placing the pulley on a shaft, all parts are accessible from the face. Made in sizes from 3 to 11 inches in diameter.



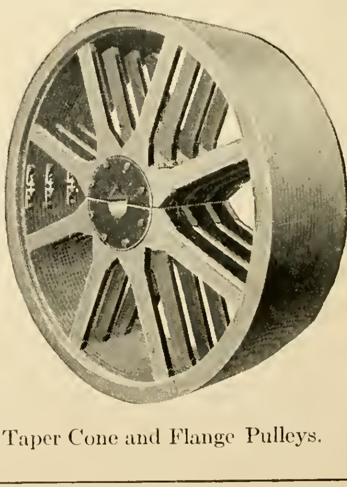
STYLE B PULLEY

Every pulley is perfectly balanced, the rims being turned inside as well as outside, and it is so constructed that it does not get out of round. The spokes are set to cut the air, not to fan it, thereby saving power. Pulleys from 12 inches to 24 inches in diameter are constructed with four sets of spokes. Sizes from 25 inches to 70 inches in diameter are made with six sets of spokes and those larger than 72 inches in diameter have eight.



STYLE D—SPECIAL PULLEY

This style has a solid web and is especially adapted for running dynamos and trip hammers, or for other extremely severe work. The iron centre is bored to exact size of shaft and is provided with key way and set screws. We can also furnish this pulley in the split pattern.



STYLE A—SPECIAL PULLEY

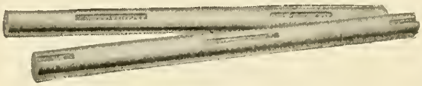
This is especially adapted for main driving, and for other extremely severe work. The rim is both nailed and glued. The spokes are securely dovetailed into and glued and nailed into the rim, and each one is set in a line running direct from the centre of the shaft to the rim—thus affording its utmost support. This pulley has a split iron centre, which is turned on the outside, bored to exact size of shaft, and key seated.

We also make Wood Bushings, Step Cone, Taper Cone and Flange Pulleys.

T. B. WOODS SONS CO.

CHAMBERSBURG, PA.

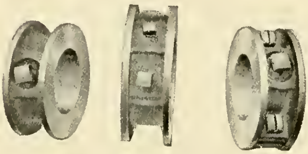
MANUFACTURING ENGINEERS, POWER TRANSMISSION MACHINERY.



Showing different forms of Keyseats

SHAFTING

Our shafting is made of the best steel and is perfectly round and straight, qualities that insure easy running and also minimum loss of power. We are prepared to furnish shafting in diameters up to 24 inches.

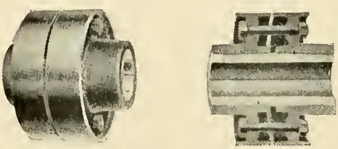


Safety Set Collar

SAFETY SET COLLARS

These are made in either solid or split for all sizes of shafting, are finished all over and fitted with hardened set screws. From the illustration it will be noticed that all bolts and set screws are protected by side flanges projecting beyond heads and nuts.

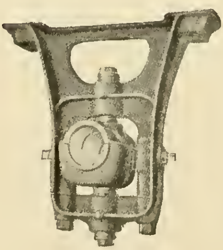
We also supply Concealed Fast Collars; these are forged from bar steel bored slightly undersize and shrunk on shaft. The turning and finishing is done after the forging is shrunk to place, thereby insuring a true running collar.



Universal Giant Compression Coupling

COUPLINGS

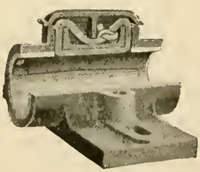
This line consists of Flange or Plate Couplings in either the Male and Female Type or Standard Plain Face Type; Double Cone Compression Couplings; Improved Collins Compression Couplings; Universal Giant Compression, the coupling that requires no keys; Ribbed Compression Couplings; Ring Compression Couplings; Shifting Jaw Clutch Couplings; Solid Sleeve Couplings and Universal Joint Couplings.



Hanger

HANGERS

While we have adopted the Ring Oiling Bearing as the standard for our Hangers, we can supply Plain Bearing with Grease Cups and the Chain Oiling Type. The Ring Oiling method is also embodied in our Double Collar End, Recessed Pattern for Concealed Fast Collar, and Closed End Bearings. Our extensive line of Hangers includes Regular and Extra Heavy Ball and Socket for Headshafts; Double Brace Adjustable Ball and Socket regular and Post Patterns; Bracket; Peerless Adjustable, Post and Pillow Blocks. Adjustable Girder Clamps and Countershafts should also be mentioned here.



Pillow Block

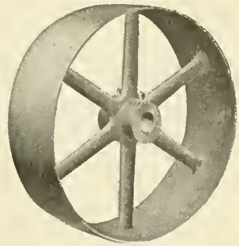
PILLOW BLOCKS, ETC.

This classification covers Solid and Split Vertical Shaft Bearing and Adjustable Step Bearings; Plain, Rigid, Rigid Quill, Extra Heavy and Standard Rigid, Pillow Blocks; Plain Flat Boxes, Solid Journal Boxes and Standard Rigid Post Boxes; Plain, Wick and Ring Oiling, Cast Iron and Steel Arch Wall Frames; Base Plates; Cast Iron Wall Brackets; Plain, Ball and Socket and Extra Heavy Ball and Socket Floor Stands; also Fire Wall Sleeves.

T. B. WOODS SONS CO.

PULLEYS

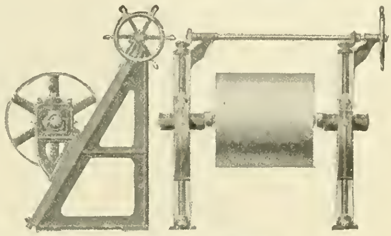
We manufacture Cast Iron Pulleys only, believing that they are superior to others because they are permanent and are suited to a wider range of service than any other type of pulley. The line comprises Plain, Split, Large Bore, Clamp Hub, Tight and Loose, Fly Wheels, Split Arm, Cork Insert, Step Cone, Taper Cone, Pulley Bushings, Stationary and Adjustable Mule Pulley Stands, Single and Double Brace Binder Frames, and Guide Pulleys.



Pulley

BELT TIGHTENERS

The upright design has triangular shaped sides, Style A has pulley and bearings set as shown in the illustration, and while in Style B these are fitted to the vertical side of the frame, Style C is a post or wall pattern. We also make Horizontal and Rack and Pinion Belt Tighteners.

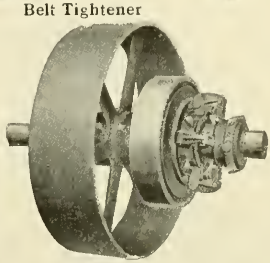


Belt Tightener

UNIVERSAL GIANT FRICTION CLUTCH WITH EXTENDED SLEEVE

This clutch is made with an extended sleeve of standard diameter, so that an ordinary pulley, gear, rope sheave or sprocket can be used by simply keying it on sleeve of clutch. It is only necessary that the bore be same as diameter of sleeve, just as if bored to fit a line shaft. This feature eliminates the expense and delay of making up special pulleys, as is usually required.

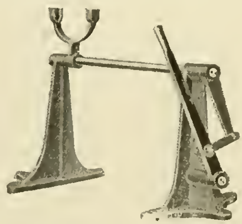
The Universal Giant Friction Clutch is designed so that the outer rim covers and protects the friction surfaces from dust, dirt, or any foreign substance. The life of all wearing parts is thus greatly prolonged and the clutch is made especially valuable for use in cement mills, phosphate factories, elevators, or any place where dust or gritty substances are afloat in the air.



Universal Friction Clutch Pulley

SHIFTERS, ETC.

We have a type which permits attaching to any of our hangers; also Fork and Lever Stands, Compound Lever, Worm Geared, Single Spur Geared and Double Spur Geared, Shifter Stands.

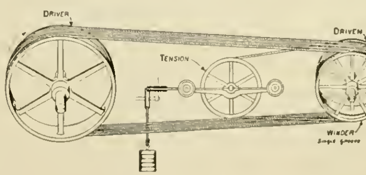


Compound Lever Shifter Stand

ROPE TRANSMISSION

We are prepared to make complete installations in either the English or American system and also furnish Rope Sheaves in various styles, Tension Carriages; Track and Track Hangers.

We have at your command engineers who have had years of experience in rope driving, and whom we will be glad to have plan a drive to meet conditions as they may exist.



Rope Drive

AUBURN BALL BEARING COMPANY

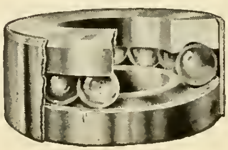
22 Elizabeth Street, ROCHESTER, N. Y.

AUBURN BALL THRUST BEARINGS; AUBURN COMBINATION THRUST AND ANNULAR BALL BEARINGS; AUBURN STEEL, BRASS, AND BRONZE BALLS.

Auburn Ball Thrust Bearings are especially adapted for High Speeds and Heavy Loads in a small space due to Auburn Patented Four Point Contact Cone Principle, illustrated by the trade mark. Specially selected tool steels properly hardened through and through in the balls and races, together with careful grinding and polishing, make Auburn Bearings most durable.

Auburn Ball Thrust Bearings are used extensively for Boring, Drilling, Milling and Screw Machinery; Lathes, Elevators and Jacks; Hydraulic and all Transmission Machinery wherever the thrust of a rotating part is to be taken care of.

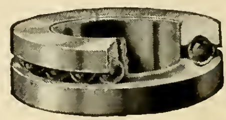
AUBURN STYLE T-100 BALL THRUST BEARING



Auburn Style T-100 bearing is a self contained ball thrust bearing. The outside retaining sleeve is attached to the lower race of the bearing with the upper race free to rotate, yet held in place. This sleeve furnishes a protection to the balls from dust and dirt, as well as making the bearing a unit. This feature greatly facilitates the assembling of the bearing on the machine and does away with the loss of balls in transit and during the operation of installing. It is a style for use in exposed places where some protection to the bearing is desired.

AUBURN STYLE T-114 BALL THRUST BEARING

Where there is a housing to protect the bearing this Auburn Style T-114 is desirable. It is also self-contained and a unit with the advantage of easy assembling on the machine. The retaining sleeve is attached to the bore of one race, leaving the other free to rotate, yet holding same in position. This is a style to use where a good circulation of oil must be had.



Auburn Ball Thrust Bearings are carried in stock for immediate shipment covering a range of shafts up to five inches in diameter, in light and heavy types. Larger sizes up to 26 inches outside diameter can be furnished promptly.

Bearings specially designed to meet unusual conditions of service can be made promptly. Write for bulletin.

WASHERS, RACES, DISCS AND RINGS

of tool steel, hardened and ground, made to customer's specifications. Our excellent facilities insure high grade work. Send Blue-Prints of sizes today for quotation.

THE HESS-BRIGHT MFG. CO.

PHILADELPHIA, PA.

MANUFACTURERS AND IMPORTERS OF ANNULAR AND THRUST BALL BEARINGS

HB HESS-BRIGHT BALL BEARINGS DWF

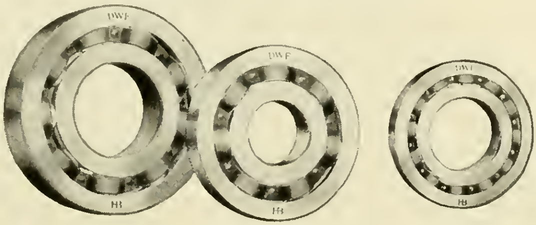
are used in

Lineshaft Hangers	Trolley Cars
Machine Tools	Woodworking Machinery
Dynamos and Electric Motors	Flour Milling Machinery

Automobiles, etc.

Special literature on request, describing the above and other applications.

ANNULAR BEARINGS



HESS-BRIGHTS of "heavy," "medium" and "light" series, for same shaft size

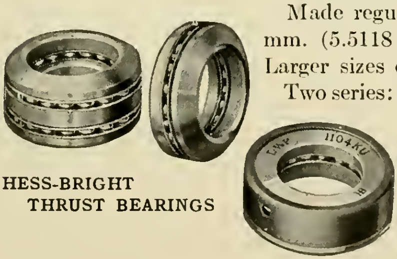
Aside from the economy in power which they make possible, Hess-Bright Ball Bearings effect important savings in repair and upkeep charges, due to the fact that wear is virtually absent.

Made regularly in sizes up to 110 mm. (4.3307 inches) shaft diameter. Special sizes to order if quantity is sufficient.

Three series: "Heavy," "Medium" and "Light," for equal shaft sizes. Regular and high-speed types.

Hess-Bright Annular Bearings are so constructed that the sides of the races are unbroken. This fact has an important bearing on durability.

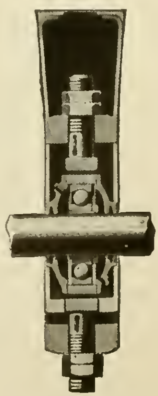
THRUST BEARINGS



HESS-BRIGHT THRUST BEARINGS

Made regularly in sizes up to 140 mm. (5.5118 inches) shaft diameter. Larger sizes on special order.

Two series: "Medium" and "Light." One-direction and two-direction types, with or without aligning washers, though the use of such washers is recommended.



Section of Ceiling Hanger

Our plants are the largest in the world devoted exclusively to ball bearing manufacture, and with the extensive enlargements and improvements which we have just made (our factories now cover approximately 15 acres of floor space), we feel justified in saying that our resources and facilities for immediate delivery are unequalled.

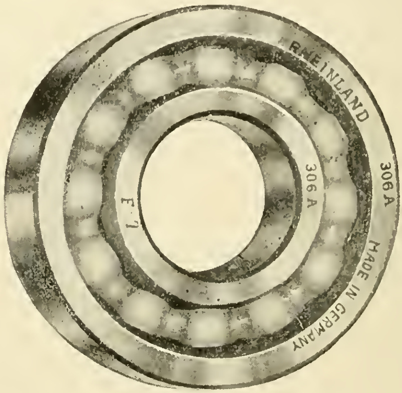
RHINELAND MACHINE WORKS CO.

140 W. 42ND ST., NEW YORK CITY

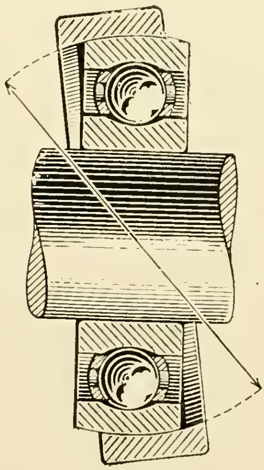
RHINELAND BALL BEARINGS

RADIAL AND THRUST BEARINGS

Rhineland Ball Bearings are made for all machinery purposes, and include every desirable type and size. Manufactured in four series: light, medium, heavy and extra heavy with corresponding load-carrying capacities.

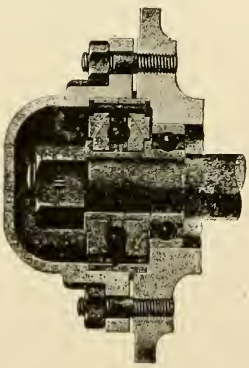


Radial Bearing


Self Aligning Bearing

SELF ALIGNING BEARINGS

The Self-Aligning Bearing is particularly suitable for line shafting and similar service, because of ability to adjust itself to any faulty alignment, its increased load capacity and permanent durability. This feature is one that will be especially appreciated by millwrights and others who have had trouble from faulty alignment with ordinary shaft bearings and with ordinary self-aligning bearings.


Double Acting Thrust Bearing

DOUBLE-ACTING THRUST BEARINGS

The Rhineland Double-Acting Thrust Bearing is a notable advance over other types in that only one row of balls is required instead of two as in other double-thrust ball bearings.

Our construction represents a decided saving in machining and other expense and also by reason of the smaller space required, gives a very great advantage in solving many problems of machine design where space is limited.

Catalogs containing full specifications and illustrations of Rhineland Ball Bearings on request.

THE METALINE COMPANY

Corporate name changed from
NORTH AMERICAN METALINE CO.
April 10, 1912

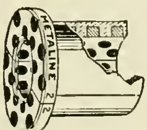
WEST AVE. NEAR BORDEN, LONG ISLAND CITY, N. Y.

METALINED OR OILLESS BEARINGS AND BUSHINGS

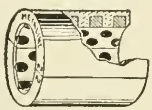
Metaline is composed of metallic oxides and other substances reduced to an impalpable powder and then solidified in hardened steel moulds under great pressure into short length plugs 3/16 in., 1/4 in. and 5/16 in. in diameter.

These plugs are inserted into holes drilled in divided bushings of gun metal bronze, phosphor bronze, or composition metal of good quality.

The two halves of the bushing having been soldered together and then machined all over to specified finished dimensions, are separated and holes drilled into the bearing surface—not all the way through the wall of the bushing—intowhich the Metaline plugs are tightly fitted and then filed flush with the bearing surface, care being taken to see that the spacing of the plugs is such that they will overlap or break joints, particularly along the line of motion.



Flanged Bushing for loose pulleys or for boxes having an end or collar bearing

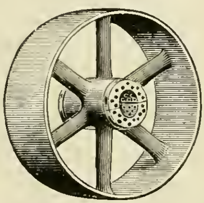


Plain Bushing for boxes or pulley block sheaves where there is no end bearing

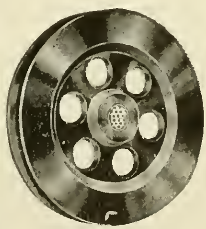
"METALINE"
(Trade Mark)
Registered in United States Patent Office, Act of Congress Approved February 20, 1905

Bearings fitted with plugs of Metaline as described above are self-lubricating, being positively oilless; indeed no oil or other lubricant should be used.

It has been proved that they last for many years, and, if the Metaline plugs are renewed before over-much wear of the bearing surface has taken place, the life of the bushing or bearing will be very greatly prolonged.



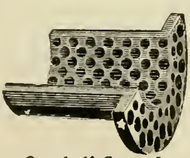
Loose pulley after being fitted with a set of two metalined flanged bushings



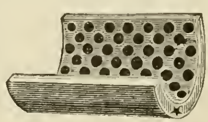
Sheave fitted with plain or unflanged metalined bushing

Cleanliness is a very desirable feature, which with the elimination of the danger of fire, a risk attending the use of fluid or semi-fluid lubricants in the other types of bearings, should particularly commend the use of Metaline.

It is conceded by the manufacturers that metalined bearings are not suitable for some lines of service; but it is claimed that these bearings give unusual satisfaction for tackle blocks, wire rope and tramway sheaves, loose pulleys, friction clutch pulleys, idler and mule pulleys, elevator pulleys and other places where the bearing revolves around the shaft; line and counter shaft boxes, floor stand boxes, ventilating fans, small motor bearings, etc.



One-half flanged bushing



One-half plain bushing

HYATT ROLLER BEARING COMPANY

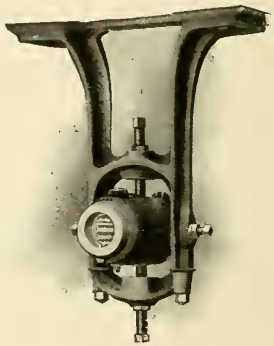
SALES OFFICE: 1120 Michigan Ave., CHICAGO

Factory, Newark, N. J. Detroit, Mich.

MANUFACTURERS OF FLEXIBLE ROLLER BEARINGS

HYATT FLEXIBLE ROLLER BEARING LINE SHAFT BOXES

Actual service covering a period of over 15 years has demonstrated the Hyatt Flexible Roller Bearing pre-eminently successful for line shaft work.

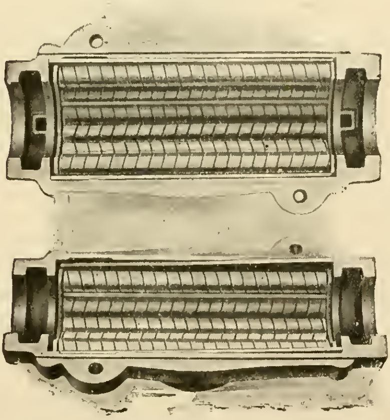


Four-Point Set Screw

The distinctive feature of the Hyatt Flexible Roller Bearing is the roller, which is made from a strip of steel wound into a coil or spring of uniform diameter. The greatest advantage of a roller of this construction is in its flexibility, enabling it to present at all times a bearing along its entire length, resulting in a uniform distribution of load on the roller itself, as well as the surfaces on which and in which it operates. All tendency, therefore, to distortion of these surfaces is entirely eliminated, for the roller will adjust itself to all irregularities that may be present, there being no necessity for hardening the various parts of the bearing, any good steel surface satisfactorily answering all requirements.

It will also be seen from its construction that the roller essentially acts as an oil reservoir, while the spiral and roller together perform the function of an oil carrier, thereby assuring perfect lubrication of all parts at all times, making it possible to operate the bearing for a considerable interval without attention.

By varying the diameter of the roller as well as the thickness, width and character of stock from which it is made, it is possible to so vary its nature as to enable it to operate under the most varied conditions, from the heaviest load on one hand to the highest speed on the other.



Halves of Split Hyatt Roller Bearing Box for Line Shafting

The box is of iron, cast in two parts and lined with steel. When assembled it is held by two large French-head screws, one at each end at opposite sides. At the top are automatic self-closing oil cups, eliminating foreign matter. At each end of the box are oil wells. A wiper is placed in the lower side, and as the oil works outward on the shaft it is caught by the wipers, and is returned to the bearings to be again taken up by the rollers.

Numerous tests have been made under all conditions of speed and load and in all classes of equipment, and in every instance have justified our claims of a saving in power from 10 to 25 per cent., depending upon local conditions.

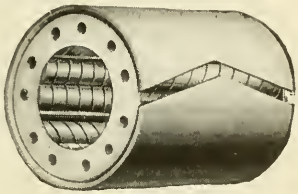
Write for Bulletin 400E.

HYATT ROLLER BEARING COMPANY

SALES OFFICE: 1120 Michigan Ave., CHICAGO

Factory, Newark, N. J. Detroit, Mich.

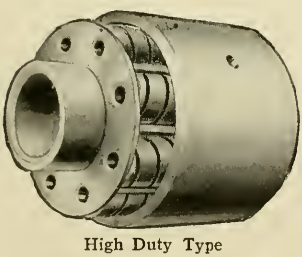
HYATT STANDARD OR COMMERCIAL TYPE



Commercial Type

The Standard or Commercial Type consists of a series of HYATT flexible rollers surrounding the shaft and contained in a yoke or cage. The ends of the cage are provided with slight projections, which hold the rollers in position when the bearing is not in the housing. These projections have nothing to do with operation of the bearing, serving only to make the bearing self-contained. Outer steel races or linings are furnished as a component part of the bearings of this type. The fundamental principle upon which the Standard of Commercial Type is based is that of generous bearing length,—thus reducing the load per unit section to a considerable extent,—the rollers of this type ordinarily are run directly upon the shaft or axle involved in the construction. The rollers are of a special analysis Chrome nickel steel properly heat-treated and ground accurately to size. This is an improvement recently incorporated in bearings of this type, the treated alloy steel superseding the high carbon steel formerly used. In this way the strength of the roller and hence its carrying capacity have been largely increased, and by presenting a harder surface its value has been still further enhanced, enabling it to operate satisfactorily under conditions where the previous type would have been over loaded. Write for Bulletin No. 600-B.

HIGH DUTY TYPE



High Duty Type

The HIGH DUTY TYPE was designed to differ from the STANDARD TYPE in making it possible to concentrate a greater load on the same length, or having the same load, to concentrate it on a shorter length. An improved yoke or cage is used as well as solid hardened and ground inner and outer races. These races, or, as termed, sleeves and linings, are carbonized and heat-treated to give hard surfaces for the rollers to operate on and then ground accurately to close limits both inside and out.

It is confidently believed that both from the standpoint of correct principle, thoroughness of development, as well as care exercised in manufacture, the HIGH DUTY TYPE presents a BEARING second to none, and the results obtained from over a million in daily service justify these conclusions. Write for Bulletin 305-A.

ROYERSFORD FOUNDRY AND MACHINE CO.

52 N. 5TH ST., PHILADELPHIA, PA.

POWER TRANSMISSION MACHINERY AND SELLS ROLLER BEARINGS

SELLS ROLLER BEARINGS REDUCE FRICTION AND SAVE SHAFTING WEAR

A close, five-minute study of the accompanying illustration will show you plainer than words why the all-split, quick-applied "Sells" is the foremost, friction-reducing, shaft-saving bearing on the market.

OLD RELIABLE SELLS ROLLER BEARINGS

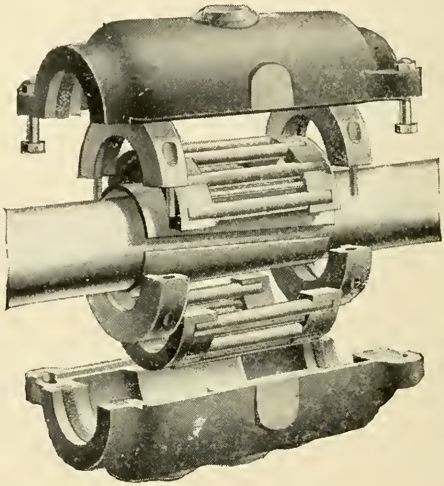
Note the split steel bushing that protects the shaft from wear, and the split collars that clamp it fixedly to the then-protected shafting. See also the split roller structure—how it separates the rollers, eliminating roll-against-roll friction, and holding them parallel to the shafting and each other.

The natural tendency with the "Sells" is for the roller structure to trail at about one-third the speed of the shafting in the same direction. It is assisted in this direction by every end-thrust against the rotating collars, which, of course, are clamped tight to the shafting. Friction is obviously eliminated at every point.

THE SPLIT BOX

The Split Box is made of a special composition, carefully machined. It is split with a milled tongue and grooved joint and the halves are bolted together.

Reservoirs for lubricant are provided and grease and drain holes are conveniently placed. Felt packing at the ends of the box retains the lubricant and excludes dust.



"Sells" Roller Bearing Boxes
With Single Roller Structure
For Line Shafts and Counter Shalts

Size of Shaft, Inches	Length of Box, Inches	Width of Box, Inches	Height of Box, Inches	Code
15/16″ & 1″	6 3/8″	2 11/16″	2 3/4″	Ibex
1 3/16″ & 1 1/4″	6 7/8″	3″	3 5/16″	Ice
1 7/16″ & 1 1/2″	7 1/4″	3 1/4″	3 11/16″	Idea
1 11/16″ & 1 3/4″	8″	3 3/4″	4 3/16″	Idiot
1 15/16″ & 2″	8 3/8″	3 15/16″	4 5/16″	Idol
2 3/16″ & 2 1/4″	9 7/8″	4 1/2″	5 1/4″	Ignite
2 7/16″ & 2 1/2″	10 1/4″	4 3/4″	5 7/16″	Ilk
2 11/16″ & 2 3/4″	10 3/4″	5 3/8″	6 1/4″	Image
2 15/16″ & 3″	11 1/16″	5 9/16″	6 1/4″	Imbibe
3 3/16″ & 3 1/4″	11 7/8″	6″	6 5/8″	Immerse
3 7/16″ & 3 1/2″	12 3/8″	6 1/8″	6 7/8″	Impose
3 11/16″ & 3 3/4″	11 7/16″	6 13/16″	7 1/4″	Imposter
3 15/16″ & 4″	15″	7 1/8″	7 3/4″	Improve
4 3/16″ & 4 1/4″	15 7/16″	7 3/4″	8 1/8″	Inapt
4 7/16″ & 4 1/2″	16 1/8″	8″	8 1/2″	Inca
4 11/16″ & 4 3/4″	16 1/2″	8 1/2″	8 7/8″	Incense
4 15/16″ & 5″	17″	8 13/16″	9 1/[illegible]″	Income

Heavy Duty "Sells" Roller Bearing Boxes
With Double Roller Structures
For Main or Jack Shafts and Heavy Belt Pulls

Size of Shaft, Inches	Length of Box, Inches	Width of Box, Inches	Height of Box, Inches	Code
1 15/16″ & 2″	13″	3 [illegible]/16″	4 [illegible]/16″	Impound
2 3/16″ & 2 1/4″	13 3/4″	4 1/2″	5 1/4″	Imprint
2 7/16″ & 2 1/2″	14 3/8″	4 3/4″	5 7/16″	Inarch
2 11/16″ & 2 3/4″	15 1/4″	5 5/16″	6 1/8″	Inborn
2 15/16″ & 3″	16″	5 1/2″	6 1/4″	Inbred
3 3/16″ & 3 1/4″	17 1/16″	5 15/16″	6 5/8″	Inclose
3 7/16″ & 3 1/2″	17 13/16″	6 1/8″	6 7/8″	Incog
3 11/16″ & 3 3/4″	19 3/16″	6 13/16″	7 1/4″	Indeed
3 15/16″ & 4″	19 3/4″	7 1/8″	7 3/4″	Indent
4 3/16″ & 4 1/4″	21″	7 3/4″	8 1/8″	Index
4 7/16″ & 4 1/2″	21 3/4″	8″	8 1/2″	Indigo
4 11/16″ & 4 3/4″	22 3/8″	8 1/2″	8 7/8″	Induce
4 15/16″ & 5″	24″	8 13/16″	9 1/8″	Infant
5 7/16″ & 5 1/2″	24 3/4″	9 5/8″	10″	Increase
5 15/16″ & 6″	26 1/2″	10 1/[illegible]″	11 [illegible]″	Incrout

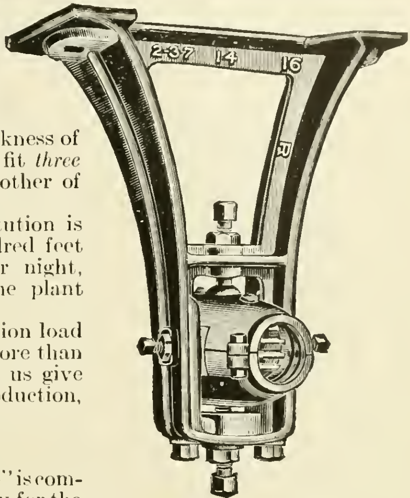
ROYERSFORD FOUNDRY AND MACHINE CO.

POWER TRANSMISSION MACHINERY AND SELLS ROLLER BEARINGS

The illustrations on this page show how Sells Roller Bearing Boxes are applied to Royersford drop hangers, post hangers and pillow blocks. They fit practically any hanger, post-hanger, or pillow block without changing existing equipment. By varying the thickness of the split bushing, the one bearing will fit *three* sizes of shafting. All expense and bother of babbitting is done away with.

As the boxes are split, the substitution is simple and inexpensive. Several hundred feet of line shafting can be changed over night, without interrupting the running of the plant during the day.

We guarantee a reduction in the friction load of 25% to 50% which annually will more than pay for the cost of substitution. Let us give you specific instances of saving in production, with figures and signatures.

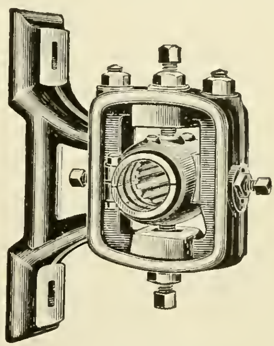


Royersford Drop Hanger

ROLLERINE

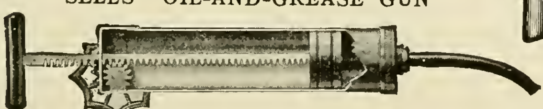
"ROLLERINE" is compounded expressly for the lubrication of "Sells" Roller Bearings and is the best lubricant for all Roller and Ball bearings. "Rollerine" contains 97% of lubricating properties and less than ½% residuum.

When "Rollerine" is used to lubricate the "Sells" Bearings, maximum efficiency is obtained, and the life of the Bearings insured under normal conditions of line-shaft service. Write for free sample.



Royersford Post Hanger

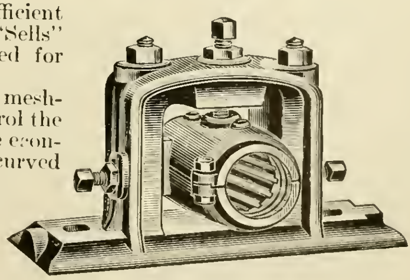
"SELLS" OIL-AND-GREASE GUN



The "Sells" Gun affords the most efficient means for applying "Rollerine" to "Sells" Roller Bearings. It is also adapted for heavy oils and greases of all kinds.

The hand wheel operating a pinion meshing in the rack makes it easy to control the amount of lubricant forced out. The economy of this is very apparent. A curved nozzle adds to the convenience in applying the lubricant.

All parts brass except the steel pinion and malleable iron hand wheel. Workmanship and material first-class. Finish throughout, high grade.



Royersford Floor Stand

BOSTON BELTING COMPANY

256 DEVONSHIRE ST., BOSTON

100-102 Reade St. New York	90 Pearl St. Buffalo	172 W. Randolph St. Chicago	55 First St. San Francisco	105 First St. Portland, Oregon

BELTING HOSE PACKING

TRANSMISSION BELTING

Brands — Excelsior Red Frictioned, Imperial stitched, Elmwood, Boston, Niagara, Trimount, Universal.

Adapted for all conditions of service; made from qualities and weaves of duck and grades of rubber which assure maximum service and economy.

GUTTA-BALATA BELTING; a high-grade textile belt, adapted for power transmission, also for conveying; so constructed that belts four-ply and heavier have absolutely seamless faces, and either side can be run next the pulleys; not injuriously affected by moderate quantities of oil or grease.

EELSKIN SOLID WOVEN COTTON BELTING made in three weights—single, double and triple; a solid, multiple-woven belt, woven under high tension, from high-grade yarns; thoroughly impregnated with a preservative compound; strong, flexible, adapted for service under practically all conditions.

CONVEYOR BELTING

Made all widths and thicknesses, with regular rubber cover, or extra thick rubber cover on one or both sides, and reinforced edges; adapted for use on straight or troughing pulleys, for carrying coal, ores, grain, gravel, sand, and other materials.

HOSE, rubber, for water, steam, gas, air, suction, oil and fire protection.

ROXBRO BRAIDED HOSE, which is furnished in continuous lengths up to 500 feet, is especially recommended for pneumatic use.

Cotton Hose, rubber-lined, furnished in light and heavy single fabrics and medium and heavy jacket fabrics; for all kinds of fire protection equipment.

Unlined linen hose, American Underwriters; supplied in all sizes and lengths, for interior fire protection equipment. Approved by all insurance interests.

PACKINGS; sheet form, for flanges and joints; adapted for all conditions of service. Piston and valve rod packings, round, square and spiral; for hot and cold water and hydraulic purposes.

RUBBER PUMP VALVES; made in all shapes and sizes for different styles of pumps and various service conditions.

RUBBER COVERED ROLLERS. New Rollers Complete. Rollers Re-covered.

High-grade coverings, made from selected gums; adapted for paper and textile mill uses, tanneries, tobacco factories, and every purpose for which rubber-covered rollers are used.

THE B. F. GOODRICH COMPANY

AKRON, OHIO

Offices in all principal cities

MANUFACTURERS OF MECHANICAL RUBBER GOODS, TIRES, ETC.

BELTING

TRANSMISSION BELTS—Main drivers require the best quality. Weight and weave of duck, amount of stretch in service, and character of cover should be considered. We recommend the following grades:

"PINNACLE"—frictioned-surface, maximum strength, extreme quality.

"TITANIC"—regular covered, extra strong and long lasting for hard service.

"PILGRIM"—regular covered, heavy duck, good friction and cover; for general service.

On small pulleys operating at high speed we recommend:

"MARATHON"—a friction surface belt of highest quality, built on special woven light, flexible duck.

Light drives, such as agricultural service, are well met by "ROB ROY," built on medium duck, and "SIGNAL," built on light weight duck.

CONVEYOR BELTS for conveying ore, coal, rock, etc., call for special qualities in the belt that have taken years of practical experience to develop. A duck of maximum strength and extreme flexibility, a strong friction, a wear-resisting cover, which will remain pliable and an edge armored against chafing are all required. We offer the following grades:

"LONGLIFE"—for severe service, where extreme wear is desired.

"MAXECON"—for ordinary service; low priced, but reliable and serviceable.

For handling grain, packages, etc., there is so little abrasion and the conditions are so dry that belts of ordinary construction can be used. We recommend our

"GRAINBELT"—medium weight duck, cover of usual thickness. Four plies common practice for horizontal conveyors. For bucket elevator belt service heavier plies are required—six plies standard. If heavier duck desired, we recommend "PILGRIM" grade.

"COSSETTE" BELT—one of exceptionally high quality throughout, for handling cossettes in beet sugar factories.

CANNING BELT, special white sanitary cover for food canning factories.

ELEVATOR BELTS for mines and quarries require a duck of extra strength, quality and weight to resist the tensile strains and the action of the bucket bolts. We use a special, tightly woven duck and recommend the following belts built on it:

"AKRON" Elevator Belt—high grade, designed for the hardest service.

"STERLING"—slightly lower grade, for general conditions, stitched when handling very wet materials.

"GOODRICH AXLE LIGHTING" belt meets the severest service known—that of the electric train lighting from the car axle.

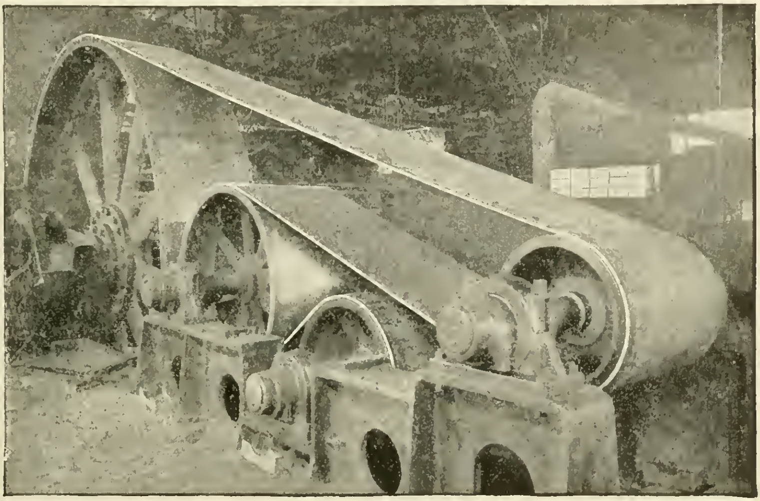
POLISHING BELTS—Sometimes called Emery Belts; built on especially strong fabric with light quality, tough friction.

We are also prepared to furnish Grader Belts, Magnetic Take-Off Belts, Separator Belts, etc.

JEWELL BELTING COMPANY

JEWELL CHROME LEATHER

Undoubtedly the most remarkable leather product of the Twentieth Century; tanned by a special process which produces a leather that isn't injured by the action of hot or cold water, steam, oil, gas and many acids.



48-in. 3-ply Chrome Belt transmitting up to 1900 horse power, at plant of Atlanta Steel Co. Atlanta, Ga. This Belt has already lasted more than 100 per cent. longer than the best oak tanned belt ever used on this drive betore.

JEWELL CHROME BELT

The Jewell Chrome leather put together with a waterproof cement making a belt that is not affected by steam, gas, water, etc., as above stated, and in addition a belt that has the greatest possible pliability combined with the greatest tensile strength and the least tendency to stretch. It will slip less on the pulleys, transmit more power per inch of width with less loss of power than any belt known. The illustration herewith is a fair sample of what it will do.

BLACK JEWELL BELT LACING

Made both in sides and cut lace; the strongest and most economical Belt Lacing known.

OTHER JEWELL PRODUCTS

Other Jewell products are Agricultural Belting, Binder Straps, Trunk Straps, Skate Straps, Fan Belts, Automobile Leathers such as Brake Bands, Clutch Facings, Straps, etc., Polishing Leathers, and

POTTER'S PATENT BELT HOOKS

MAIN BELTING COMPANY

PHILADELPHIA

NEW YORK — CHICAGO — BOSTON
PITTSBURGH — SEATTLE — BIRMINGHAM

MAIN BELTING CO. OF CANADA, LTD.

MONTREAL — TORONTO — CALGARY

LEVIATHAN
ELEVATING
TRANSMITTING
CONVEYING
BELTING

Leviathan Belting has withstood all manner of tests for more than thirty years, and it is today the most serviceable belting made for elevating, transmitting and conveying.

It is sold strictly for its service value, on the principle that the man who buys a belt is interested chiefly in *quality of service* and regards price as of minor consideration. For this reason, Leviathan Belting is not in competition with other belting—it is simply the best belting for service.

You buy Leviathan under a guarantee which continues our responsibility beyond payment until the belt has earned in actual service its full cost as compared with the service of any other belt of any kind, under the same or similar conditions.

Every piece of Leviathan measures up to the four chief requirements of the ideal belt—strength against stretching, ample traction, wearability and resisting qualities.

ANACONDA, THE SPECIAL BLACK COMPOSITION BELT

Our Anaconda Belt is made of the regular high-grade heavy Leviathan canvas, specially treated to give it resisting qualities under all sorts of extraordinary conditions. It is not only waterproof, but is also capable of withstanding a high degree of temperature.

It is the belt to use for transmitting and conveying under conditions involving exposure to high temperature, steam, water or rough weather.

THE ROSSENDALE-REDDAWAY BELTING AND HOSE COMPANY

NEWARK, N. J., U. S. A.

"CAMEL HAIR" BELTING, CANVAS STITCHED BELTING, SOLID COTTON BELTING, ARABIAN "ASBESTOS BRAKE LINING"

"CAMEL" BRAND "CAMEL HAIR" BELTING

This belt is remarkable for its great strength (almost twice that of the leather belting), long lite, small slippage, minimum stretching, straight true running, and for the fact that it is less affected by dampness or acid fumes than any other kind of belting. This belting is also sold under a guarantee that it will give longer, better service than any other style of belting running under the same conditions. Made in four thicknesses as follows:

SINGLE "CAMEL" which corresponds to single leather or to 4-ply canvas and rubber.

MEDIUM "CAMEL" which corresponds to heavy single leather or to 5-ply canvas and rubber.

DOUBLE "CAMEL" which corresponds to double, and heavy double leather or to 6- to 8-ply rubber and canvas.

Extra heavy "Camel" to correspond to triple leather and all extra heavy types of belting.

STITCHED CANVAS BELTING "SPHINX BRAND"

Thoroughly equal to the best on the market in this type of belts, and affords economy if substituted as follows:

8-ply in place of double leather or 5 and 6-ply rubber.
6-ply in place of light double leather or 5-ply rubber.
4-ply in place of single leather or 3-ply rubber.
10-ply where extraordinary strength is required.

Made in all weights.

"BLACK-BIRD" WOVEN COTTON BELTING

FOR TRANSMISSION AND CONVEYOR WORK

An improved woven belt manufactured under high tension from the finest quality of long-staple cotton.

Impregnated with a special composition which protects the fibre, keeps the belt pliable, and prevents it from becoming hard and dry.

Will run well in steamy or wet places and on drives exposed to the weather.

ARABIAN "ASBESTOS BRAKE LINING"

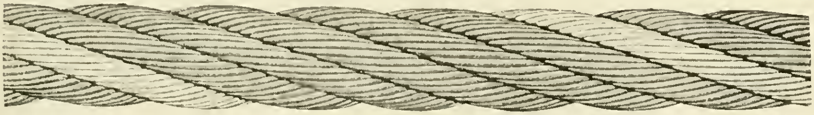
Especially suitable for automobile brakes. Made in all widths from one to four inches. Standard thicknesses $\frac{3}{16}''$ and $\frac{1}{4}''$.

BRODERICK & BASCOM ROPE CO.

NEW YORK — ST. LOUIS — SEATTLE

Factories, St. Louis and Seattle

WIRE ROPE AND AERIAL TRAMWAYS



YELLOW STRAND

The strongest of all Steel Ropes

Compare the figures in the table below with those of any Plow Steel wire rope. Then you will have the real reasons for Yellow Strand's greater durability and resulting economy.

Yellow Strand's great strength permits the use of smaller rope for the same work, or heavier work with the same size rope. Its unusual flexibility gives it long life on derricks and for similar uses where the sheaves are small and the work heavy.

YELLOW STRAND WIRE ROPE

19 wires to the strand. Hemp center

TELEGRAPH NAME	Diameter in inches	Circumfer. in inches	Approx. weight per foot	Approx. strength tons 2000 lbs.	Prop. work load tons 2000 lbs.	Diam. drum or sheave feet advised
Noggin	¼	¾	.10	3.15	.63	1
Nopal	5/16	1	.15	4.50	.9	1¼
Norma	⅜	1⅛	.22	6.75	1.35	1½
Nugget	7/16	1¼	.30	9.4	1.9	1¾
Nabob	½	1½	.39	12.1	2.4	2
Nachar	9/16	1¾	.50	14.5	2.9	2¼
Nacon	⅝	2	.62	19	3.8	2½
Nadir	¾	2¼	.89	26.3	5.3	3
Namur	⅞	2¾	1.20	35	7	3½
Nectar	1	3	1.58	45	9	4
Nelson	1⅛	3½	2	56	11	4½
Nero	1¼	4	2.45	69	14	5
Neptune	1⅜	4¼	3	84	17	5½
Newton	1½	4¾	3.55	98	20	6
Nina	1⅝	5	4.15	110	22	6½
Nimrod	1¾	5½	4.85	133	27	7
Nocent	1⅞	5¾	5.55	150	30	8
Nomad	2	6¼	6.30	166	33	8
Nolta	2¼	7⅛	8	210	42	9
Nucleus	2½	7⅞	9.85	263	53	10
Nurse	2¾	8⅝	11.95	315	63	11

Yellow Strand is also made with 7 wires to the Strand, and with wire center.

Grade for grade, our other brands of wire rope are just as superior as our Yellow Strand. Try B. & B. Plow Steel, Crucible Cast Steel, Patentsteel and Swedes Iron Elevator Ropes. They last longer.

Order direct or through any authorized agent. There is one in your locality.

Catalog No. 2D on request.

JOHN A. ROEBLING'S SONS CO.

TRENTON, N. J.

WIRE ROPE OF ALL KINDS

ROEBLING

We manufacture and keep in stock at our works at Trenton and at warehouses, at agencies and branches in large cities wire rope made from Swedish Iron, Cast Steel, Extra Strong Cast Steel, Plough Steel and Improved Plough Steel.

We give below tables of strengths, etc., for the standard constructions of IMPROVED PLOUGH STEEL ROPE. The rope is also furnished with 6 strands of 37 wires each and with 8 strands of 19 wires each.

This rope is recommended as the best to use where extreme conditions tend to bring extraordinarily severe stresses, and is particularly well adapted to resist abrasion.

The hemp center of this rope is colored blue to distinguish it from other wire ropes.

A copy of our catalogue, giving information about other wire ropes, and wire rope fastenings will be mailed on application.

IMPROVED PLOUGH STEEL HOISTING ROPE

Composed of 6 Strands and a Hemp Center, 19 Wires to the Strand.

Trade Number.	Diameter in inches.	Approx. circumf. in inches.	Approx. weight per foot.	Approx. strength in tons of 2000 lbs.	Proper working load in tons of 2000 lbs.	Dia. of drum or sheave in feet advised.
00	2¾	8⅝	11.95	315	63	11
0	2½	7⅞	9.85	263	53	10
1	2¼	7⅛	8	210	42	9
2	2	6¼	6.30	166	33	8
2½	1⅞	5¾	5.55	150	30	8
3	1¾	5½	4.85	133	27	7
4	1⅝	5	4.15	110	22	6½
5	1½	4¾	3.55	98	20	6
5½	1⅜	4¼	3	84	17	5½
6	1¼	4	2.45	69	14	5
7	1⅛	3½	2	56	11	4½
8	1	3	1.58	45	9	4
9	⅞	2¾	1.20	35	7	3½
10	¾	2¼	.89	26.3	5.3	3
10¼	⅝	2	.62	19	3.8	2½
10½	9/16	1¾	.50	14.5	2.9	2¼
10¾	½	1½	.39	12.1	2.4	2
10a	7/16	1¼	.30	9.4	1.9	1¾
10b	⅜	1⅛	.22	6.75	1.35	1½
10c	5/16	1	.15	4.50	.9	1¼
10d	¼	¾	.10	3.15	.63	1

IMPROVED PLOUGH STEEL ROPE

For Haulages and Transmissions. 6 Strands and a Hemp Center, 7 Wires to the Strand.

11	1½	4¾	3.55	90	18	11
12	1⅜	4¼	3	79	16	10
13	1¼	4	2.45	67	13	9
14	1⅛	3½	2	52	10	8
15	1	3	1.58	42	8.4	7
16	⅞	2¾	1.20	33	6.6	6
17	¾	2¼	.89	25	5	5
18	11/16	2⅛	.75	20	4	4¾
19	⅝	2	.62	17½	3.5	4½
20	9/16	1¾	.50	13	2.6	4
21	½	1½	.39	11	2.2	3½
22	7/16	1¼	.30	7¾	1.5	3
23	⅜	1⅛	.22	6½	1.3	2½

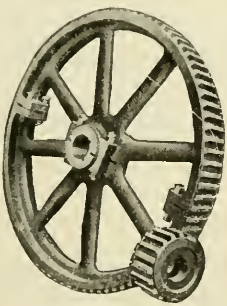
H. W. CALDWELL & SON COMPANY

CHICAGO, ILLINOIS

ELEVATING, CONVEYING AND POWER TRANSMITTING MACHINERY

HELICOID CONVEYOR

Sole manufacturers of "HELICOID" SCREW CONVEYOR. Made of one continuous strip of metal without lap or rivet. Mounted on standard and extra heavy pipe or solid shaft.



GEARS

Machine Molded Teeth or Cut Teeth, Spurs, Bevels, Miters, Mortise Wheels, 1″ to 6″ pitch.

CHAIN

Standard Malleable Detachable Special, Steel Chains for all purposes.

SPROCKET WHEELS

With Chilled Rims and Teeth for hard service.

ELEVATOR BUCKETS

Salem, Caldwell Avery made of Steel, also Special Steel Buckets of all kinds made to order. Malleable Buckets for stone, coal and gritty materials.

STEEL WORK

Elevator Casings, Conveyor Troughs, Spouting Tanks, Pan Conveyors, Elevator Boots.

Belt Conveyors for stone, sand, grain, coal, etc.

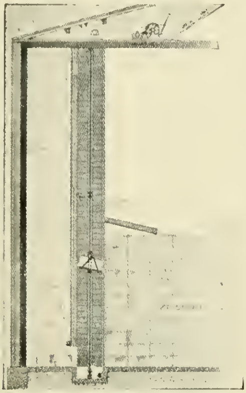
Send for catalogue No. 34

Pulleys, Fly Wheels, Shafting, Bearings, Friction Clutches, etc.

GIFFORD-WOOD CO.

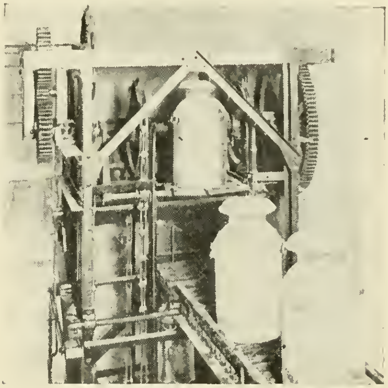
BOSTON — HUDSON, N. Y. — CHICAGO

ELEVATING AND CONVEYING MACHINERY; ICE TOOLS

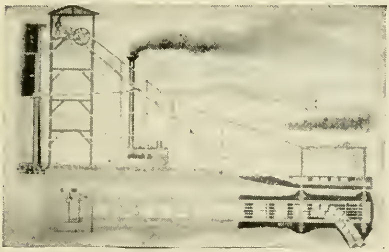


Gig Elevating and Lowering Machine

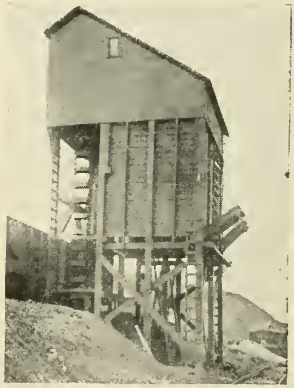
Automatic Lowering Machine



Milk Can Elevator

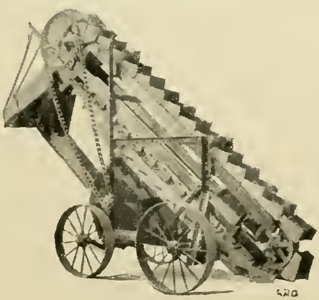


Ice Elevator

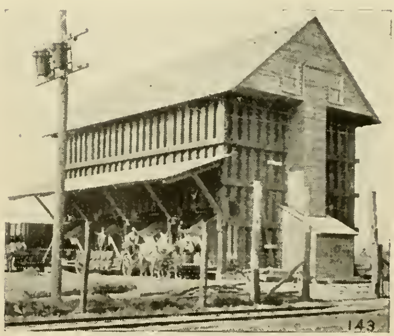


R. R. Coaling Station

Ice Elevator



Wagon Loader



Model Coal Pocket

Send for catalogs and other information desired.

WELLER MANUFACTURING CO.

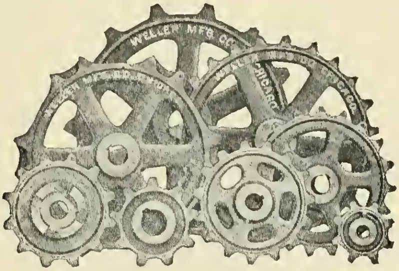
CHICAGO, ILLINOIS

ENGINEERS, FOUNDERS, MACHINISTS AND SHEET METAL WORKERS. MANUFACTURERS OF ELEVATING, CONVEYING AND POWER TRANSMITTING MACHINERY. COMPLETE GRAIN ELEVATOR EQUIPMENTS.

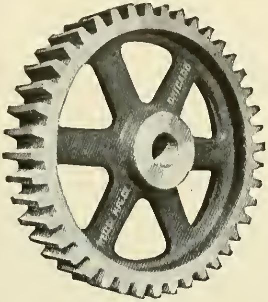
The complete catalogue of the Weller Manufacturing Co., covering a complete line of elevating, conveying and power transmitting appliances, comprises a volume of about 600 pages. We have endeavored to give in the following list, however, enough to indicate the range of their activities in these lines.

Angle plates for bevel and miter gears
Apron Conveyors
Barrel Elevators
Bearings, ring oiling, chain oiling, self oiling
Belt tighteners
Belting, Rubber, Canvas, Leather.
Blocks, Tackle
Buckets, Elevator
Cars, Steel Dump
Chain, Case hardened steel bushed, combination steel and malleable, detachable lock pintle, etc., etc.
Clutches, Friction, Square and Spiral Jaw
Collars
Conveyors, Belt, Spiral, Endless Chain
Couplings, Compression, Flanged face, Universal
Dump Cars
Elevator Appliances, including Buckets, Boots, heads, legging both steel and Wood, Power shovels, etc., etc.
Fans, for elevator heads, steel plate exhaust
Friction Clutches
Friction Hoists
Friction Wheels
Gears, Spur, Bevel, Cogs, Worm, etc.
Grease Cups
Hangers, Drop, Post
Hoists, American Safety rope, double drum, Moore anti-friction chain, single drum friction
Jack Screws, Locomotive
Link Belting and attachments
Manila Rope Transmission appliances
Oil Burners
Paper Frictions
Perforated Metal
Pillow Blocks
Pipe, plain riveted, spiral riveted
Power Shovels
Pulleys, cast iron, head, friction clutch, steel split, wood split, etc.
Shafting
Sheaves, manila rope transmission, wire rope transmission, wire rope hoisting
Sprocket Wheels
Spur Rack and Pinion
Take up Boxes
Tension Carriages
Trippers for Belt Conveyors
Winches, Hand and Power
Wire Cloth

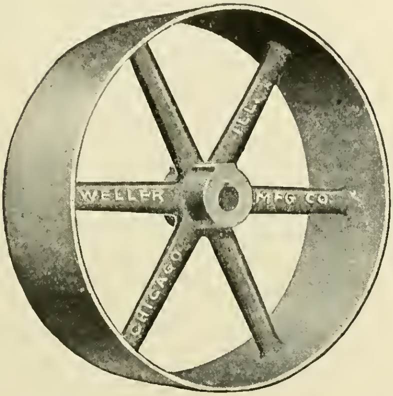
WELLER MANUFACTURING CO.



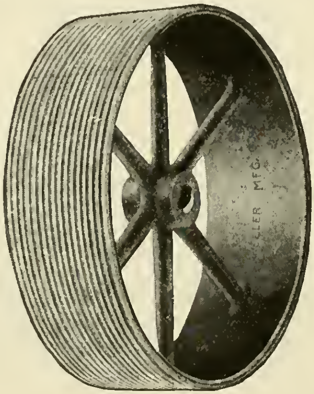
Sprockets



Gears

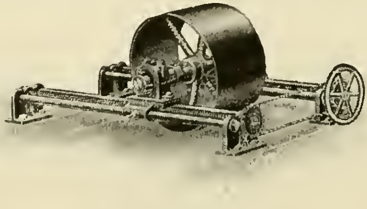


Pulleys

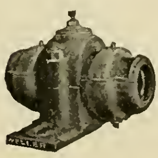


Sheaves

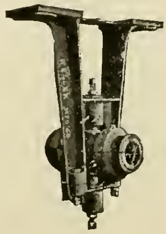
Dump Cars



Belt Tighteners



Pillow Blocks



Hangers

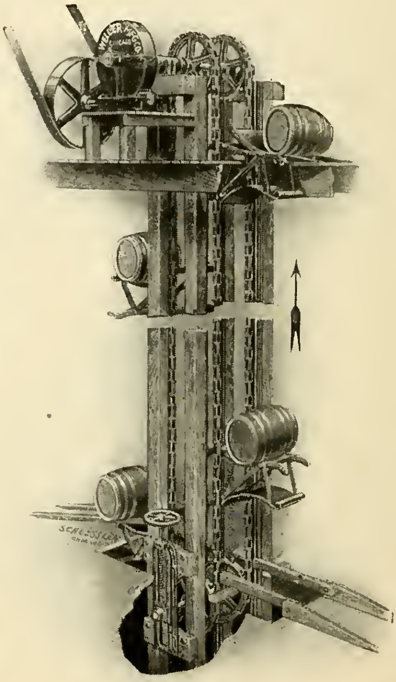
(See also next page)

(Continued from preceding pages)

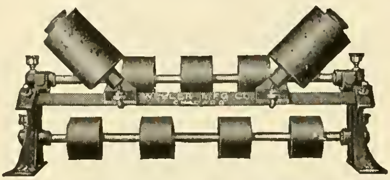
WELLER MANUFACTURING CO.

CHICAGO, ILLINOIS

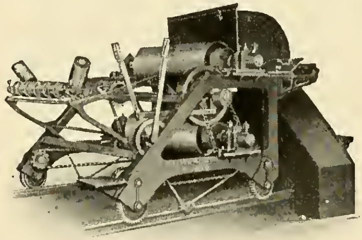
Spiral Screw Conveyor



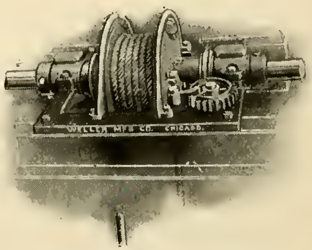
Barrel Elevator



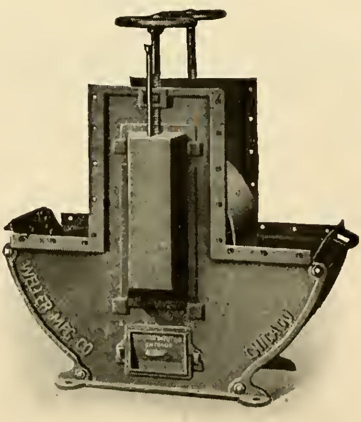
Belt Conveyor Troughing Rolls



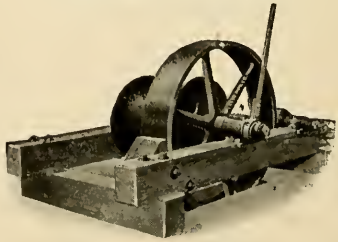
Trippers



Weller Improved Power Shovel



Standard C. I. Elevator Boot



Friction Hoist

VULCAN IRON WORKS

WILKES-BARRE, PA.

LOCOMOTIVES, HOISTING AND HAULAGE ENGINES, AIR COMPRESSORS, MINING AND CEMENT MACHINERY

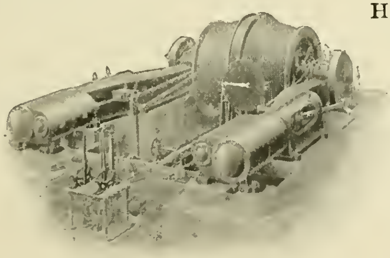
LOCOMOTIVES

Steam Locomotives. The Vulcan Iron Works make a specialty of, and have excellent facilities for, building locomotives to meet the needs of contractors, steel, mining, and industrial plants; and for plantation, logging, freight, switching and passenger service, in all styles and weights from seven to seventy tons on drivers. A separate and complete plant is devoted to this work.

We also endeavor to keep on hand full detail parts of standard types with a view of making deliveries on short notice. Our stock locomotives can be forwarded on receipt of lettering instructions.

Complete illustrated catalog on request.

Compressed Air Locomotives are adapted to general service in and around coal mines, or industrial plants where a fired locomotive would be dangerous. The dimensions, pressure and capacity of the tanks may be modified to suit special requirements and conditions. For very long runs a separate air tender can be provided, which may be attached or detached as desired. Detailed information on request.



HOISTING AND HAULAGE ENGINES

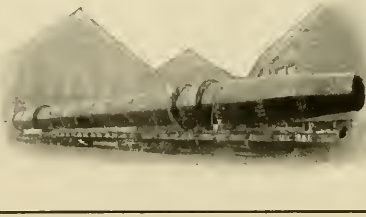
First Motion Hoists. These engines are built to the most rigid specifications for heavy hoisting work. The drums are of steel or iron, grooved and conical in shape so as to counterbalance the weight of the rope. The illustration shows a type used for shaft hoisting from 300 to 1000 ft. lifts fitted with steam reverse, steam brake, and the Nicholson Engine stop for the prevention of overwinding. Special catalog on request.

Geared Engines. Vulcan Geared Engines are used ordinarily where a hoisting speed of 800 ft. per minute or less is satisfactory, and for some purposes are preferred over First Motion Hoists because of the lesser first cost and of the smaller space occupied. These engines are simple and compact, but have ample proportions in all working parts so as to insure great durability and consequent low cost of maintenance. Special catalog on request.

Vulcan Electric Hoists. Vulcan Electric Hoists are built in standard sizes from 35 to 250 H.P. and with single or double drums. Special hoists will be designed to meet special conditions as may be required. If desired the equipment includes solenoid brakes and a device for the prevention of overwinding.

MACHINERY FOR THE MANUFACTURE OF PORTLAND CEMENT

We build Kilns for either the dry or wet process, and of any size to suit the needs or ideas of the customer. Although our specialty is rotary kilns, dryers and coolers, we also build engines, boilers, stacks, bins, sheet iron work of all kinds, conveying and elevating machinery, and other machinery used in or around the Modern Portland Cement Plant.



Catalog on request.

NORDYKE & MARMON CO.

Established 1851

1320 Kentucky Ave. INDIANAPOLIS, IND.

FLOUR AND CEREAL MILLING MACHINERY ; ELEVATING, CONVEYING AND POWER TRANSMITTING APPLIANCES.

FLOUR AND CEREAL MILLING MACHINERY

Aspirators
Bag Filling Machines
Barley Machinery
Blenders, Flour
Bolters, Flour, Meal and Special products
Buckwheat Machinery
Cleaners, Corn and Grain
Conveyors
Coolers, Meal
Crushers, Corn
Degerminators, Corn
Distillers' Machinery
Dressers, Flour
Dryers, Meal
Dumps, Wagon
Dusters, Bran
Fans, Exhaust or Ventilating
Flour Mill Machinery, "All Kinds"
Grain Cleaning and Grading Machinery
Grain Elevator Machinery & Appliances
Heaters, Grain
Hullers, Rice
Mill and Factory Supplies

THE RIPE EXPERIENCE of more than sixty years of successful manufacturing is embodied in every machine and mill or factory accessory produced by Nordyke & Marmon Company. In every way that counts for the user's benefit they are second to none.

Each new device and machine is subjected to a gruelling test under actual operating conditions before it goes on its way to a prospective user. It is this rigid standard of service and responsibility to the ultimate user that has made Nordyke & Marmon Company known the world over as "America's Leading Mill Builders."

The list shown above gives you an idea of the different machines we build for your use. Our catalogs tell you in further detail why these machines fulfill your requirements so thoroughly. A letter will bring a catalog describing any machine you need—write it now.

Mills, Buhr Stone
Mills, Feed Grinding
Mills, Roller
Movers, Car
Oat Meal Machinery
Packers, Bran
Feed, Flour & Meal
Power Transmitting Machinery
Pulverizing Machinery
Purifiers, Flour & Meal
Reels, Bolting
Roll Grinding and Corrugating
Rope Transmission Machinery
Scalpers, Corn (Round, Reel and Hexagon)
Screening Machinery
Separators, Dust
Shellers (Corn), Hand and Power
Sieve, Starch
Sifters, Flour, Meal, etc.
Starch Factory Machinery
Steamers, Grain
Take-ups, Belt & Rope
Temperers, Corn and Grain

NORDYKE & MARMON CO.

ELEVATING, CONVEYING AND POWER TRANSMITTING APPLIANCES

Although best known as manufacturers of Flour and Cereal Mill Machinery, the Nordyke & Marmon Co. are also large manufacturers of Elevating, Conveying and Power transmitting appliances. We present herewith a partial list of our products in this line, and a few illustrations to show the symmetrical and powerful lines along which they are designed.

Our general price list No. 1320 contains brief descriptions and complete tables of prices, dimensions and weights.

We contract to furnish complete mechanical equipment for flour mills, corn mills, cereal mills, starch and rice mills, with or without power plant from the smallest to the largest capacities, furnishing detailed building and machinery plans.

A large and complete stock of mill supplies is carried from which orders are promptly filled.

We solicit inquiries for prices, estimates and information.

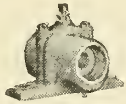
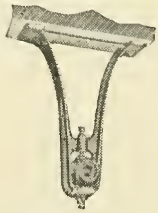
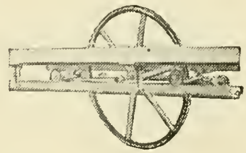
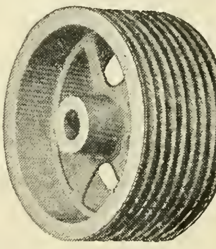
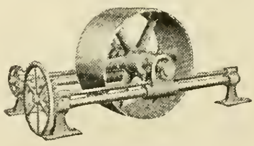

Ring Oiling Bearing


Plate Type Coupling


Adjustable Ball and Socket Drop Hangers


Horizontal Tension Carriage Double Track


Finished Iron Sheaves
For Manila Rope Transmission


Screw Belt Tightener
Horizontal and Upright


Bevel Mortise Gearing


Mitre Gearing

- Attachments, sprocket chain
- Bearings, double, eccentric, elevator boot, flange, flat, floor, floor stand, hanger, journal, pedestal, pillow block, post, rigid flat, rigid vertical, ring oiling, roll feeder, step, take-up, universal, upright, vertical
- Belt clamps
- Belt conveyor appliances
- Belt tighteners
- Belting, canvas stitched, cotton, leather, rubber
- Bevel gears
- Boots, elevators—cast iron, galvanized iron, wood
- Brackets, wall
- Buckets, elevator
- Chain, sprocket
- Clutches, friction, aw
- Cogs, wood
- Collars, safety set
- Conveyors, belt, flight, helicoid, spiral
- Countershafts, variable speed
- Couplings, clamp, cog, compression, conveyor, finger, flange, friction clutch, jaw clutch plate
- Cups, elevator
- Elevators
- Frames, sectional wall
- Gears, bevel, spur, mitres, internal
- Hangers, conveyor, drop, post
- Hardwood conveyor flights
- Heads, elevator: galvanized iron, sprinkler, standard
- Hoisting crabs
- Hoisting cranes
- Hoisting screws
- Jacks
- Keyseating
- Laces, belt
- Link belt
- Link belt attachments
- Linings, conveyor
- Manila transmission rope
- May-Oborn chain
- Movers, car
- Pillow blocks
- Plates, anchor, arch leveling, pulley, sole or base, toe, tram
- Post hangers, adjustable, double rigid
- Power grain shovels
- Pullers, car
- Pulleys, cast iron, clamp hub, flanged, friction clutch, rope, solid, split, tight and loose
- Rack tighteners
- Rolls, belt conveyor
- Rope, Manila transmission
- Rope, sheaves
- Rope, wire
- Scales
- Set screws
- Shafting
- Sheaves, rope, rubber filled
- Speed indicators
- Stands, floor, pulleys
- Take-up boxes
- Tension carriages
- Tighteners, belt
- Tracks for tension carriages
- Triple conveyor bearings
- Troughing rolls and carriers
- Vertical shaft bearings
- Wall box frames
- Weights for tension carriages
- Wheels, sprocket
- Wood boxes for conveyors
- Wood shaft conveyor
- Wrenches

STEPHENS-ADAMSON MFG. CO.

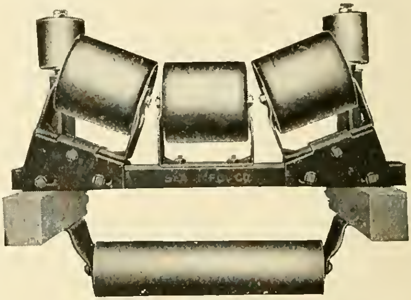
AURORA, ILLINOIS

CHICAGO, NEW YORK, PITTSBURG, ST. LOUIS, SAN FRANCISCO, LOS ANGELES, BOSTON

CONVEYING ENGINEERS; CONVEYING, SCREENING, AND TRANSMISSION MACHINERY.

"S-A" BELT CONVEYORS

In the design of this machinery, we have led particularly in its application to contracting work—handling sand and gravel in washing and concrete mixing plants, and handling excavations and dam-fills. Our experience along these lines makes our engineering service particularly helpful.



S-A Ball Bearing Unit Carriers

THE "S-A" UNIT CARRIER

is an all-steel ball bearing carrier, possessing the following advantages:

Construction—The Unit Carrier is made up of individual Unit Rolls, supported in steel brackets which are mounted on steel channels arranged to meet any requirements.

Easy Running—The ball bearings reduce the power required 33 1-3 per cent on level runs.

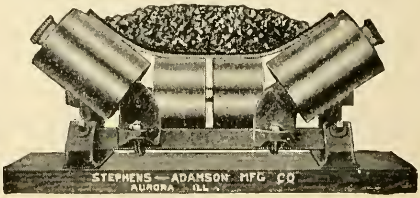
No Lubrication—The ball bearings (dust-proof) eliminate the constant attention required for lubrication and thus reduce the labor cost.

Strength and Light Weight—The steel construction with individual supports for each roll gives the strongest and the lightest carrier made. Each single unit will safely stand a load of 1,000 lbs.

Adjustment—The Unit Construction allows perfect flexibility and ease of adjustment to all changes of size, degree of concentration, etc.

STYLE No. 9 CARRIER

This carrier has direct lubrication to well-babbitted bearings outside the conveyor belt. It is mechanically correct and is the highest development of this type of conveyor carrier. Many miles of conveyors are operating over these carriers under all conditions. The bearings are dust-proof and the strength is adequate to all demands.



Style No. 9 Carrier

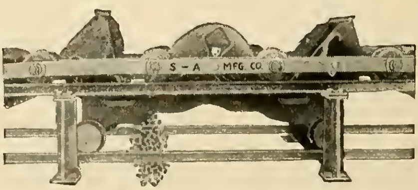
THE "S-A" IMPROVED PIVOTED BUCKET CARRIER

The Power Plant Conveyor

For handling coal and ashes in power plants, for handling cement clinker, etc.

No Spill. The lips of the buckets overlap perfectly, so that no particles of the material are spilled in transit.

Perfect Discharge. Each bucket turns completely over at the tripper, loosening sticky material and emptying all particles of dust or grit.

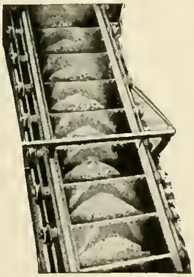


S-A Improved Pivoted Bucket Carrier

Malleable Iron Buckets. The buckets are not affected by temperature. Grit cannot wear the buckets or get into the bearings.

Perfect Alignment. The supporting shaft of each bucket passes thru both links of each chain and holds the chains in their proper upright position.

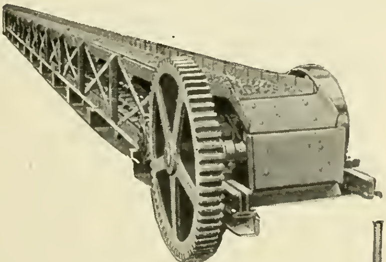
STEPHENS-ADAMSON MFG. CO.



72-inch "S-A"
Jumbo Conveyor

GRAVEL WASHING AND ROCK CRUSHING EQUIPMENT

We have designed and equipped hundreds of these plants—commercially successful—in all parts of the country. The steel pan conveyor illustrated here, which is the largest ever built, is handling crushed stone in the plant of the Tomkins Cove Stone Company. It handles a capacity of 1,000 tons per hour up an incline of 45 degrees. The steel buckets are six feet in length and are supported by graphite-bushed self-lubricating steel rollers connected by double steel bar link chains. Many of our large conveyors of this type are in use throughout the country.



"S-A" Steel Pan Conveyor

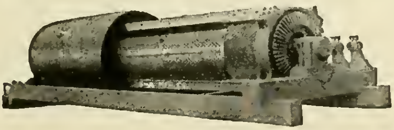
"S-A" STEEL PAN CONVEYORS

To meet the increasing demand for conveyors of large capacity and reliability, we build several types of steel pan conveyors. These conveyors are absolutely reliable and produce high conveying economy.

Protected Screw Take-ups

PROTECTED SCREW TAKE-UPS

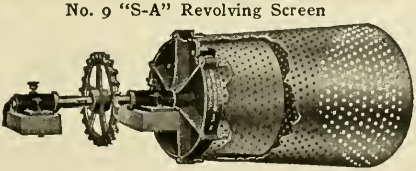
This style of take-up has a standard bearing mounted on a steel angle base. The angle protects the screw, brings the bearing lower and makes a more powerful and compact take-up than any other type.



No. 9 "S-A" Revolving Screen

"S-A" REVOLVING SCREENS

This type of revolving screen is designed for the severest crushing plant service. We also make many types of screens for lighter service.



"S-A" Improved Gilbert Screen

"S-A" IMPROVED GILBERT SCREEN

The standard screen for washing sand and gravel. The inner skirt takes the greatest wear and triples the life of the outer screen.

OUR MANUFACTURES AS ILLUSTRATED IN OUR GENERAL CATALOG INCLUDE THE FOLLOWING LINES

Bearings
Belt Conveyors for all applications
Brushes, Revolving, for conveyors
Buckets, Elevator, steel and malleable
Cars
Car Hauls
Car Pullers and movers
Chains, standard detachable, malleable and steel of all types
Clutches, friction and jaw
Coal Handling Equipment for pockets, power stations, washeries and tipples
Coal Crushers
Conveyors, belt, pan, chain for handling ore, coal, ashes, gravel, crushed rock, clay, cement, and all bulk or package products
Elevators, chain and belt, for all applications
Feeders, conveyor, apron, roll and shaking
Gates
Gears
Glass Works Conveyors
Gravel Plant Equipment, washing and screening
Hangers
Pillow Blocks
Pulleys
Screens, shaking and revolving for all applications
Sheaves
Spouts
Sprockets
Transmission Systems and Equipment

WILLIAMS PATENT CRUSHER AND PULVERIZER CO.

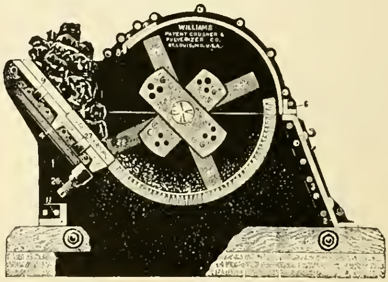
OLD COLONY BLDG. CHICAGO.

WORKS
St. Louis

BRANCH OFFICES
New York San Francisco Philadelphia Pittsburgh

CRUSHING AND GRINDING MACHINERY

COAL CRUSHERS FOR COKE OVEN WORK, BY-PRODUCT AND BEEHIVE OVENS.



By the use of the Williams Patent Hammer Crushers with the various adjustable features, the following results are obtained from the ovens: The oven pulls easier, more coke is made from each oven, the ash is reduced, the coke comes out firm, regular in size, does not crumble, and the structure is much improved.

The substantial construction of these machines is plainly shown in this cut; all parts subject to wear are easily adjustable, which includes the hammers, the discs, the cage bars, and the breaker plates. The housing is entirely protected from wear by heavy liner plates made of heavy chilled iron. The machine is very accessible, as it is made of sectional construction.

Specifications Regular Crusher

Size Mill	Hopper Opening	Size Feed	Capacity Tons Per Hour			Speed	Size Pulley		Extreme Dimensions			Horse Power	W'ght
	In.		½″ & finer	¼″ & finer	⅛″ & finer	R.P.M.	Diam.	Face	L'gth	Wdth	H'ght		P'nds
1	15x12	Run of Mine	30– 40	25– 30	20– 25	1000	20″	15″	6′	6′6″	3′9″	20–25	6500
2	20x12		45– 55	40– 50	30– 40	1000	20″	15″	6′	7′6″	3′9″	30–35	7500
3	30x16		65– 80	60– 70	45– 60	1000	20″	15″	6′	8′6″	3′9″	50 60	9500
4	40x18		100–115	80– 90	60– 80	1000	24″	18″	6′	9′0″	3′9″	75–80	10500
5	50x20		120–140	100–110	75–100	1000	24″	20″	6′	9′6″	3′9″	100	12000
6	60x20		150–175	115–130	100–120	1000	24″	22″	6′	11′0″	3′9″	125	13500
					Jumbo Specifications								
5	30x24	R.O.M.	150–175	120–140	80–100	750	24″	18″	8′10″	9′	5′4″	85–100	20000
6	36x24		180–200	145–165	120–140	750	30″	20″	8′10″	10′	5′4″	140–150	21000
7	48x30		225–250	200–220	150–175	750	30″	24″	8′10″	11′	5′4″	165–185	28000
8	60x30		275–300	250–275	180–200	750	30″	24″	8′10″	13′	5′4″	200–250	30000

CRUSHERS FOR ANTHRACITE MINE REFUSE

Our Patent Hinged Hammer Debris Crushers are in extensive use for properly crushing and treating Anthracite debris or Culm before flushing it into the mines.

Specifications Debris Crushers

Size Mill	Hopper Opening	Size Feed	Capacity Tons Per Hour			Speed	Size Pulley		Extreme Dimensions			Horse Power	W'ght
	In.		¾″ & finer	½″ & finer	¼″ & finer	R.P.M.	Diam.	Face	L'gth	Wdth	H'ght		P'nds
1	15x12	Run of Mine	30	20	15	1000	20″	15″	6′	6′6″	3′9″	20–25	6500
2	20x12		40	35	25	1000	20″	15″	6′	7′6″	3′9″	25–30	7500
3	30x16		65	50	35	1000	20″	15″	6′	8′6″	3′9″	40–50	9500
4	40x18		80	70	60	1000	24″	18″	6′	9′0″	3′9″	75–80	10500
5	50x20		115	85-100	75	1000	24″	20″	6′	9′6″	3′9″	100	12000
6	60x20		130	110-125	90-100	1000	24″	22″	6′	11′0″	3′9″	125	13500

We also crush Coal and Pitch for Briquette Plants—for Coal Washers, before and after washing, and make a specialty of sizing Coal for all Commercial Purposes.

WILLIAMS PATENT CRUSHER AND PULVERIZER CO.

CRUSHERS FOR CHAIN GRATES OR STOKERS

The Williams Patent Coal Splitter takes Run of Mine Coal and reduces the same to 1½", 1¼", 1", ¾" and finer with the "*minimum amount of fine dust*," the *only* machine made that can be *regulated* to properly *size coal.* All parts are *adjustible* to *wear;* the crusher is also *adjustable* to give most *any* size coal *desired.*

Brief Specifications

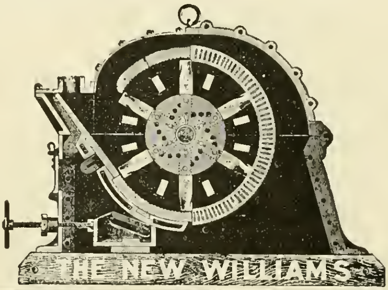
No. of Crusher	Hopper Opening, Inches	Weight	Horse Power	Capacity—Tons Per Hour R.O.M. to 1½" and Finer
1	15 x 12	6,500	15 to 20	25 to 40
2	20 x 12	7,200	20 to 25	50 to 60
3	30 x 16	9,500	40 to 50	75 to 100
4	40 x 18	10,500	60 to 75	100 to 125
5	50 x 20	12,000	85 to 100	135 to 175
6	60 x 20	13,500	100 to 125	180 to 220
7	48 x 36	22,000	135 to 175	250 to 275
8	60 x 36	30,000	200 to 250	300 to 375
9	60 x 40	40,000	275 to 350	400 to 500

WRITE FOR COMPLETE COAL CATALOG No. 30.

RAW MATERIAL GRINDERS FOR CEMENT AND GYPSUM PLANTS

UNIVERSAL MILL

This *Universal Grinder* is the *only* machine of its kind made. Will take DRY 2" Limestone, Shale, Clay, or Coal, and deliver at one operation a product 95% through 20 mesh, TUBE MILL FEED WITHOUT OUTSIDE SCREENS OR SEPARATORS. *No other* machine can deliver the fine uniform product year in and out.



Complete Specifications Universal Mills

Size Mill	Size Feed	Diam Mill	Capacity Per Hour Dry Stone Tons		Speed	Horse Power	Floor Space Extreme Dimensions			Size Pulley		W'ght
			12 Mesh	20 Mesh	R.P.M.		L'gth	Width	Height	Face	Diam.	P'nds
0	1 "	18"	¾	½	1800	10–12	5'	5' 1"	3'2"	8½"	8"	2500
1	1½"	26"	2–4	1–3	1600	15–20	6'3"	5'10"	3'8"	10½"	16"	4000
2	1½'	26"	5–6	3–5	1600	20–25	6'3"	6' 3"	3'8"	12½"	16"	5000
2xx	2 "	26"	6–8	5–6	1600	30–35	6'3'	7'	3'8"	15 "	20"	6500
3	2 "	40"	10–12	8–10	1100	50–60	7'6"	6'10"	5'4"	15 "	20"	12000
4	2½"	40"	13–15	10–13	1100	65–75	7'6"	7'10"	5'4"	18 "	20"	14000
5	2½'	40"	16–20	15–18	1100	80–100	7'6"	8' 6"	5'4"	20 "	20"	16500
9	3 "	60"	25–35	20–30	750	150 175	12'	9' 2"	7'2"	24 "	30"	30000

VULCANITE RE-CRUSHER

These Vulcanite grinders will take raw material, limestone, shale, clay or coal, in cubes of 3 inches and under, and reduce the same to ½ inch or ¼ inch. This makes an excellent feed for those plants which use roller mills as finishers in the raw end.

Vulcanite Specifications

Size Mill	Hopper Opening	Size Feed	Capacity Tons Per Hour			Speed	Horse Power	Extreme Dimensions			Size Pulley		W'ght
			½"	⅜"	¼"	R.P.M.		L'gth	Width	Height	Diam.	Face	P'nds
1	14"x 5"	1½"	4	3	2	1500	15–18	4'8"	6'3"	3'3"	16"	10½"	4200
2	18"x 6"	2 "	7	5	3	1500	20–25	4'8"	6'6"	3'3"	16"	12½"	5000
2xx	24"x 6"	2 "	10	8	6	1500	30–35	4'8"	7'	3'3"	20"	15 "	6000
3	18"x 8"	2½"	20	18	15	1000	40–50	5'2"	7'	4'	20"	15 "	10000
4	24"x 8"	3 "	30	27	25	1000	70–75	5'2"	7'4"	4'	20"	18 "	12000
5	30"x 8"	3 "	35	30	28	1000	90–100	5'2"	8'	4'	20"	20 "	14000
6	36"x10"	3 "	40	35	30	1000	110–125	5'2"	9'	4'	20"	22 "	15500
7	40"x10"	3 "	50	42	35	1000	125–150	5'2"	9'6"	4'	22"	24 "	17500

WRITE FOR CEMENT CATALOG No. 33.

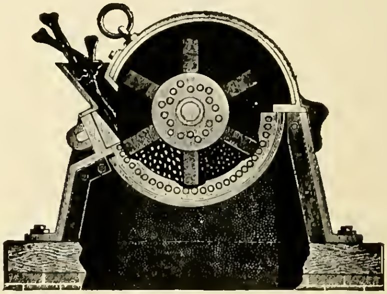
(See also following pages)

(Continued from preceding pages)

WILLIAMS PATENT CRUSHER AND PULVERIZER CO.

BONE, TANKAGE, SHELL AND FERTILIZER GRINDERS

The Williams Grinders are so well known in the general Fertilizer field that we do not deem it advisable to go into any lengthy explanation as to just what they will do on Fertilizer material, for we have over 400 in operation; we will, however, give below a few uses for these machines on Bone and Tankage.



They successfully grind Steamed and Junk Bone, Packing House and Garbage Dry Tankage, Raw Bone, Clam and Oyster Shells, Beef Scraps and Cracklings, Corn, Cob and Cereal, etc.

Specifications Regular Bone Mills

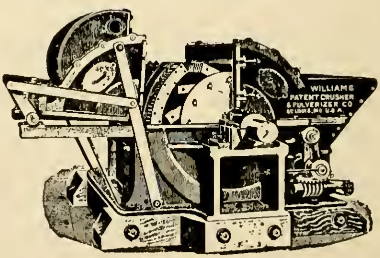
Number of Machine	Dimensions of Hopper Opening	Size of Feed	Capacities Approximate Per Hour			Pulley Dimensions		Speed	Horse Power Approx.	Dimensions Approximate Extreme			Approx. Weight Heaviest Piece	Weight Approx. Total Lbs. Net	Weight Approx. Total Lbs. Gross
			Mesh 10 Dry Tankage	Mesh 8–10 Steamed or Dry Bone	Mesh 1/8–5 Green or Raw Bone	Dia.	Face	Rev. Per M.		Length	Width	Height			
00	8x4	3″	300 lbs.	500 lbs.	250 lbs.	8	6½	2600	5–7	3′2″	4′ 1″	2′6″	300	1400	1500
0	12x5	4″	1500 lbs.	1 ton	1000 lbs.	8	8½	1800	10–12	3′6″	5′ 1″	2′6″	325	1900	2000
1	14x6	4″	1 ton	1½ tons	1500 lbs.	16	10½	1600	20–22	4′8″	5′10″	3′3″	575	3650	4000
2	18x6	4″	1-2 tons	2½ tons	2500 lbs.	16	12½	1600	25–30	4′8″	6′ 3″	3′3″	575	4200	4500
2xx	24x6	4″	2-3 tons	4 tons	2 tons	20	15	1600	30–35	4′8″	7′	3′3″	575	5000	5600
3	18x8	5″	4-5 tons	6 tons	4 tons	20	15	1000	40–45	6′	6′10″	4′2″	1030	7500	8000

WRITE FOR COMPLETE FERTILIZER CATALOG No. 35

CHIP SHREDDERS

For Turpentine, Alcohol, Extract Plants and Pulp Mills

The *ease* with which this machine is *opened* for *repairs* or *inspection* is noticeable. The cover is *split vertically* in the center and held with "*hinged*" *bolts*, the back, or movable half of cover is attached to an *actuating mechanism* which *raises* and *moves* this *back half* of cover. *One man* moves a lever and the cover *slides backwards with ease.*



When wishing to open machine *one man* loosens 4 *nuts* on *hinged bolts*, swings bolts clear of cover, takes hold of lever and slides *cover backwards* and *out of his way*, the work of *five minutes*.

The operator can then inspect or remove *hammers, cages, discs,* or any other *internal part.*

This is an *innovation* found on *no other* similar machine and is another point of "*accessibility*" so *prominent* in the *Williams shredders.*

The log wood, stumps or offal from Southern saw mills is first put through a Hog or Chipper, and reduced to about the size of an *ordinary hand*, it is then passed to a *Williams shredder* where it is reduced to a *fine uniform product*, easily handled and in excellent shape for the extraction of Turpentine, Rosin, Chips for Pulp and Extract.

WILLIAMS PATENT CRUSHER AND PULVERIZER CO.

Specifications Chip Shredders

No. of Mill	Hopper Opening	Size of Feed	Capacity per Hour Tons			Pulley Inches		Speed	Horse Power	Extreme Dimensions			W'ght Gross	W'ght Net
			3/8"	1/4"	1/8"	Dia.	Face	R.P.M.		L'gh	Width	H'ght	P'nds	P'nds
0	12"x 5"		3/4	1/2	1/4	8"	8½"	2000	10	3'6"	5' 1'	2' 6"	2000	1800
1	14"x 5"		2	1	1/2	16"	10½"	1200	18	4'8"	5'10"	3' 2"	4200	3800
2	18"x 6"		3	2	1	16"	12½"	1200	22	4'8"	6' 3"	3' 2"	4800	4200
2xx	24"x 6"		4	3	1½	20"	15 "	1200	30	4'8"	7'	3' 2"	5500	5000
3	18"x12"		5	4	2½	20"	15 "	1000	40	6'	6'10"	3'11"	8000	7500
4	24"x12"	Whole	7	6	4	20"	20 "	1000	60	6'	8'	4' 2"	9500	9000
5	30"x12"	Chips	10	8	6	20"	22 "	1000	75	6'	8' 6"	4' 2"	10500	10000
6	36"x12"		12	10	8	20"	24 "	1000	85	6'	9'	4' 2"	11000	10500
7	40"x12"		16	15	10	20"	24 "	1000	100	6'	9' 6"	4' 2"	12000	11500
8	48"x12"		19	17	12	22"	24 "	1000	120	6'	10'	4' 2"	14000	13000
9	54"x12"		22	20	15	22"	26 "	1000	140	6'	11'	4' 2"	15000	14000
10	60"x12"		24	22	18	22"	30 "	1000	165	6'	12'	4' 2"	17000	16000

These Capacities vary with Condition of Chips, also Operating Conditions—Likewise Variation in Horse Power.

WRITE FOR SHREDDER CATALOG No. 38

CRUSHERS AND GRINDERS FOR GENERAL WORK

Limestone, Shale, Clay, Coal, Gypsum, Lime, Oil Cake, Bone, Tankage, Oyster and Clam Shells, Guano, Phosphate Rock, Fish Scrap, Marl, Natural Cement, Fire Clay, Calcined Clays, Tobacco Stems, Ochres, Kaolin, Corn Cobs, Peat, Barytes, Mica, Sugar, Salt, Stick-Lac, Stucco, Feed of all kinds Chemicals of all kinds, and many other materials.

Specifications Oil Cake Grinders

Size Mill	Hopp'r Ope'ng	Size Feed	Capacity Tons Per Hour				Size Pulley		Sp'd	Horse Power	Extreme Dimensions			W'ght
	Inches	Using Breaker	Nut	Pea	Fine Meal	Nut, Pea & Meal	Dia.	Face	R.P.M.		L'gth	W'th	H'ght	P'nds
00	8x4		1	3/4	1/2	3/4	8"	6½"	2000	4– 6	3'6"	4'1"	2'6"	1400
0	12x5		1½–2	1–1½	1	1	8"	8½"	1800	8–10	3'6"	5'1"	2'6"	2000
1	15x6		2½–3	1½–2	1½	1½–2	16	10½	1600	15– 18	4'8"	5'10"	3'2"	3650
2	18x6	Whole Cakes	3– 4	2½–3	2	2½–3	16	12½	1600	20– 25	4'8"	6'3"	3'2"	4500
2xx	24x6		5– 6	3– 5	3	3– 5	20"	15"	1600	30– 35	4'8"	7'	3'2"	5300
3	18x8		8–10	6– 8	5	6– 8	20"	15"	1000	40– 60	6'	6'10"	4'2"	8000
4	24x8		10–12	8–10	6	8–10	20"	18"	1000	70– 80	6'	8'	4'2"	9500
5	30x8		12–15	10–12	8	10–12	20"	20"	1000	80–100	6'	8'6"	4'2"	12000

Larger Sizes Built to Order.

WRITE FOR OIL CAKE CATALOG No. 39

Specifications Clay and Shale Grinders

Size Mill	Hopper Op'ning	Size Feed	Approx. Cap'city Brick per 10 Hrs.		Size Pulley Inches		Speed	Horse Power	Extreme Dimensions			Wgh't
	Inches		Medi'm Size Grind'g	Fine Grind'g	Dia.	Face	R.P.M.		Len'th	W'dth	Height	P'nds
1	10x14	6"	25000	20000	20	10½	1400	30–35	7' 3"	6'6"	4'11"	8500
2	20x12	7"	30000	25000	20	15	1400	40–45	7' 3"	7'0"	4'11"	9500
3	30x12	8"	40000	30000	20	15	1400	55–60	7' 3"	8'0"	4'11"	11500
4	40x12	8"	45000	40000	20	17	1400	70–75	7' 3"	9'0"	4'11"	15000
5	30x16	From	55000	45000	20	18	1000	80–90	8'10"	9'6"	5'10"	18500
6	40x16	Steam	65000	60000	24	20	1000	100–110	8'10"	10'6"	5'10"	22000
7	50x16	Shovel	80000	75000	24	22	1000	125	8'10"	11'7"	5'10"	25000
8	60x16	"	100000	85000	24	24	1000	150	8'10"	12'6"	5'10"	27000
9	70x18	"	120000	100000	24	26	1000	175	8'10"	13'6"	5'10"	28500
10	80x18	"	130000	120000	26	26	1000	200	8'10"	15'0"	5'10"	30000

WRITE FOR CLAY CATALOG No. 40

Mention material you wish to crush or grind and we shall see that you receive the proper catalog.

THE ALLIANCE MACHINE CO.

ALLIANCE, OHIO

New York
Pittsburgh

Chicago
Birmingham

ENGINEERS AND BUILDERS OF ELECTRIC TRAVELING CRANES AND MACHINES OF ALL TYPES FOR ALL PURPOSES; I-BEAM HOISTS; ORE BRIDGES; ROLLING MILL AND HYDRAULIC MACHINERY, RIVETERS, STEAM HAMMERS, HEAVY PUNCHES AND SHEARS; COKE PLANT MACHINERY, SCALE CARS AND CHARGING LARRIES; COPPER CONVERTING MACHINERY.

ELECTRIC TRAVELING CRANES AND MACHINES

Those successful concerns whose names are known everywhere in the mechanical and business world are using the following types of cranes and machines designed and built by us:

Electric Traveling Ladle Cranes
Electric Traveling Soaking Pit Cranes
Electric Traveling Stripper Cranes
Electric Traveling Bucket Cranes
Electric Traveling Charging Machines
Electric Traveling Gantry Cranes and Ore Bridges
Electric Traveling Coke Pushers
Electric Traveling Coke Levelers

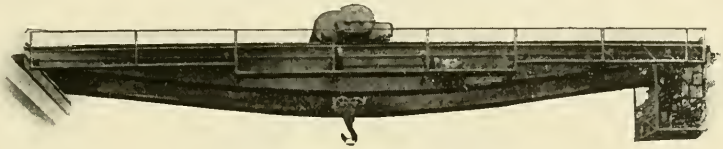
The accompanying cut shows a 200-ton Electric Traveling Crane designed and built by us for the Carnegie Steel Co.'s Homestead Works, for the Open Hearth and Armor Plate Department. This crane is probably the largest single trolley electric traveling crane in service and is illustrated here to show the capacity of our works for producing large machinery. We make a specialty of cranes for steel works and heavy industrial service.

NORTHERN ENGINEERING WORKS

DETROIT, MICH.

ELECTRIC TRAVELING CRANES, ELECTRIC HOISTS, ELECTRIC AND HAND CRANES OF ALL TYPES, COAL HANDLING AND HOISTING MACHINERY, FOUNDRY EQUIPMENT.

ELECTRIC TRAVELING CRANES

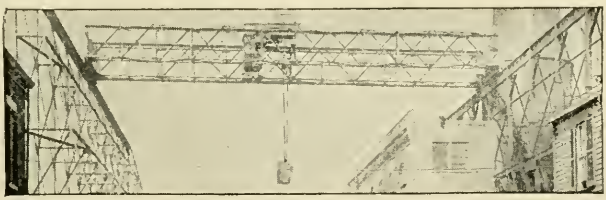


Standard Type E Northern Crane

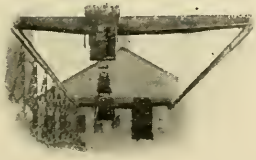
We make a specialty of Electric Traveling Cranes of from 1 to 150 tons capacity, for either direct or alternating current. The Type E Trolley is our Standard Trolley. We also make Mill Crane Trolleys and Cranes to conform to the mill crane specifications of various steel mills.

Northern Cranes have many exclusive features in the line of safety attachments and for that reason are of interest to safety engineers and to those firms who have studied the problem of reducing accidents to the minimum.

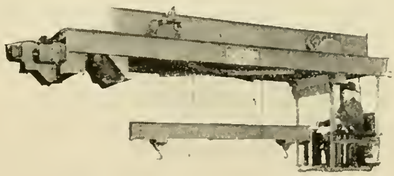
Our Standard Type E enclosed construction has many advantages from the operating side. The strong construction, durability of working parts, bath lubrication, and accessibility and simplicity are all features regularly furnished. For protection to employees, Type E Crane has all gears enclosed, no gears overhung, all bearings capped, safety limit stops, footwalk, and other modern features.



Electric Traveling Bucket Crane



Special Bucket Crane



Special Mono-Rail Hoist

In addition to Electric Traveling Cranes, which form the greater portion of our output, we build Hand Traveling and Locomotive Cranes, Jib Cranes and Gantries, and design special cranes for all purposes. Coal-Handling Cranes and Mono-Rail equipment for hoisting and conveying. Also Portable Electric Hoists and a line of Foundry Equipment such as Cupolas, Ladles and Elevators, Trucks and Turntables.

C. W. HUNT COMPANY, INC.

WEST NEW BRIGHTON, STATEN ISLAND, NEW YORK

New York City Office: 45 Broadway

COAL AND ASH HANDLING MACHINERY, PIVOTED BUCKET CONVEYORS, HOISTING AND CONVEYING MACHINERY, CABLE AND AUTOMATIC RAILWAYS, STEEPLE TOWERS, SKIP HOISTS, INDUSTRIAL RAILWAY EQUIPMENTS, ELECTRIC LOCOMOTIVES, MOTOR CARS, TRANSMISSION AND HOISTING ROPE, SPECIAL SCALES AND WEIGHING HOPPERS, COAL CRACKERS.

Single Door Charging Car

Industrial Railway in a Foundry

INDUSTRIAL RAILWAYS AND CARS

The boiler room cars for bringing coal to boilers are so designed that the labor of firing is reduced to a minimum, and the boiler room is kept clean. We design all types of cars for use in foundries, machine shops and all kinds of manufacturing plants. The use of outside flanged wheels permits one man to push a one ton load on a sharp curve. Ask for catalog on "Industrial Railways."

PIVOTED BUCKET CONVEYORS

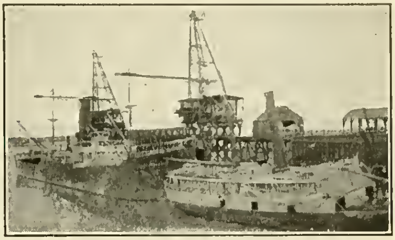
consist of a series of independent swinging buckets free to dump in either direction. Conveyors can run in any direction, the buckets hanging in an upright position, therefore dry or liquid material can be handled. The peculiar system of driving by a pawl relieves the conveyor wheels of all stress. Ask for catalog 12-9 on Conveyors.

C. W. HUNT COMPANY, INC.

WEST NEW BRIGHTON, NEW YORK

HUNT STEEPLE TOWERS

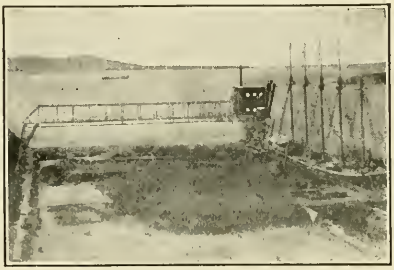
are designed to be operated by one engineer. One engine is required for hoisting the steam shovel and another for running the trolley on the booms. Great speed makes these outfits especially suited to rapid unloading of vessels. The projecting booms are usually hinged to swing horizontally over the wharf. Where obstructions such as the rigging of vessels interfere, the booms can fold up in a vertical plane. Capacity of buckets ranges from ½ to 2½ tons.



Hunt Steeple Towers

HUNT TRANSPORTING BRIDGES

are adapted to the storage and reclaiming of coal over large areas. The one shown has a four-drum equalizing engine and operates with grab buckets at a capacity of 120 tons per hour. Furnished in capacities up to 600 tons per hour.

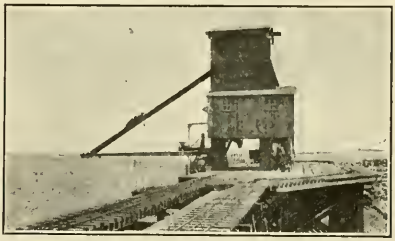


Hunt Transporting Bridges

INCLINED BOOM HOISTING ELEVATORS

are for rapid and economical hoisting of materials from vessels. The bucket, whether large or small, is carried from the hold of the vessel to the dumping place every trip in exactly the same course, and at any rapidity demanded. The bucket is carried exactly where wanted, rising vertically from the hold to the boom, running up the boom, and dumping at a fixed place.

These elevators are proportioned to suit the work and for use either with tubs or grab buckets. The lighter size is especially adapted for coal or ore hoisting, using any size bucket up to one-ton capacity.

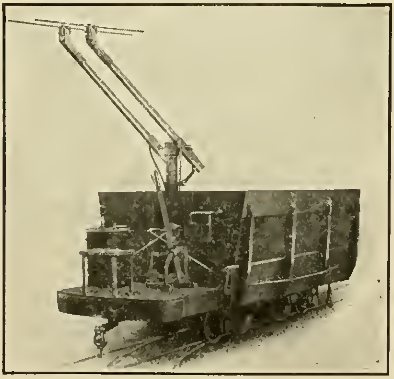


Inclined Boom Hoisting Elevators

HUNT MOTOR CARS
Self-Dumping

made in many types, capacities up to 10 tons, and are equipped with motors and overhead trolleys or shoes for third rail as desired. Suitable for transporting coal, fertilizer materials, ores, and other bulk materials.

Catalogs on request.



Hunt Motor Cars
Self-Dumping

AMERICAN STEEL & WIRE COMPANY

THE BLEICHERT SYSTEM OF AERIAL TRAMWAYS

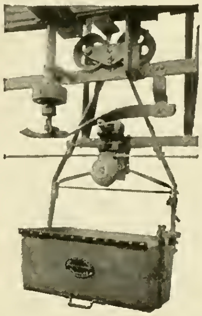


Fig. 4 Carrier with Webber Patent Compression Grip, showing patent automatic attacher

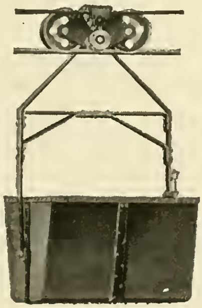


Fig. 5 Carrier with Bleichert Patent Automatic Overhead Grip

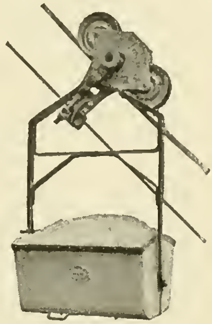


Fig. 6 Carrier with Bleichert Patent Automatic Underhung Grip

the smooth surface of which conduces toward a very uniform wear, which adds to the life of the cable and of the wheels that run on it.

These cables are made of a select grade of steel, in lengths varying from 500 to 1500 ft. which are joined by patented steel couplings illustrated in Fig. 3.

The grips for attaching the carriers to the traction rope are simple in construction, powerful, strong and efficient.

They are made for ropes running below or above the track cables according to the exigencies of the case, as shown in the cuts above. Fig. 4 represents the ordinary form of carrier with underhung grip suspended from a terminal rail, in the act of being mechanically attached to the traction rope. Fig. 5, a carrier with the Bleichert patent automatic overhead grip; and Fig. 6 a carrier with the Bleichert patent automatic underhung grip.

In the latter two the grips form an integral part of the carriage construction and operate in such a way that the weight of the carriers in any case acts as the gripping force in closing the jaws against the rope. These grips, therefore, are independent of any nice adjustment of the jaws and automatically accommodate themselves to irregularities of the rope which is a great advantage in long lines.

An overhead grip with positive operating mechanism is also made.

Well tried devices are provided for attaching and detaching the grips automatically at the terminals and other stations as may be required.

No buttons, lugs, or knots of any kind are required on the traction rope. This fact adds greatly to the life of the rope, since the wear is distributed uniformly over the entire rope and not confined to certain spots.

The same advantage pertains to these grips as compared to permanent connections of any kind. The ability to strip the line readily of its carriers when occasion occurs for resplicing the traction rope, or while making repairs is of itself a very great advantage.

Receptacles especially designed for any purpose are made of all kinds of materials. Buckets are most commonly used as shown in the illustration above, and these may be self-dumping if desired.

By cars especially designed to hold one or more buckets, the material may be transferred to and from surface tracks at the stations without rehandling.

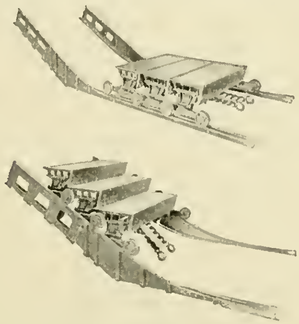
Scales are furnished, if desired, specially designed for weighing the loaded carriers, or counters for automatically registering the number transported.

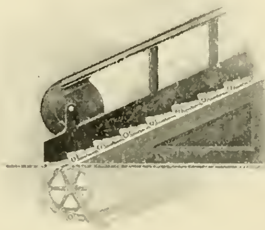
OTIS ELEVATOR COMPANY

ESCALATORS

The problem of inter-floor travel, where it is necessary to keep thousands of people moving constantly and rapidly, has been successfully solved by the Escalator, due to its continuity of motion and its enormous capacity—approximately 11,000 people can be carried in an hour without overloading the machine.

There are two types of Escalators, known as the Step and Cleat types. The Step type begins as a moving platform, rising slowly into a perfect staircase as it breaks into steps. The Cleat type is an endless moving platform formed of hardwood cleats located in longitudinal ridges and grooves.





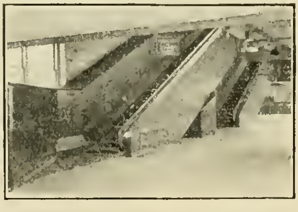
Step Type

As shown above, on the landing the treads are flush—the passenger stepping onto them from a stationary floor plate. Approaching the incline a step formation is produced and on the incline, the full riser development. At the upper end, the reverse action takes place and the steps flatten out into a moving platform again, from which the passenger alights smoothly to the stationary floor.

Cleat Type

The step treads are nearly horizontal at an angle of $12\frac{1}{2}$ degrees. The platform revolving over the sprocket glides through the prongs of a comb at the lower level and journeys upward at a moderate speed. At the upper landing it disappears through a comb and revolving over a sprocket, travels downward. The passenger slides off upon the prongs of the comb at top without jar or shock.

In each type, on either side, a hand rail of flexible material moves upward at the same speed as the treads. An electric motor drives the mechanism running on rollers on an inclined plane, which supports the treads. The Escalator can be made to operate either up or down by employing a reversing switch. The Duplex Escalator handles traffic in both up and down directions simultaneously, two machines being used.



Escalators are now being operated in large railway terminals, elevated and subway stations of the big cities, theatres, department stores, and in large mills and factories.

The cut shows two of the eight Step Type Escalators installed in the largest worsted mill in this country. The eight escalators carry 6,500 operators between the 2nd and 6th floors, moving noon and night. Individual trip from 2nd to 6th floor consumes two minutes. The machines are motor driven and can be started, stopped and reversed at will. They operate a total of one hour per day, low motor powers being used, and the annual operating costs are very small. In the course of a year a large sum of money is saved through the conserved energy of the employees. Catalogue on request.

GRAVITY SPIRAL CONVEYORS

Open Spiral Type

For moving speedily and safely heavy cases, barrels, and bulky factory products from an upper level or floor to a lower level. Provided with chain and fusible link doors which close automatically in case of fire. We have installed conveyors of this type which are handling the products of 10 floors.

Made with single and double spirals, with or without a supporting core. Closed types are made with single, double and triple spirals. Booklet on request.

THE ELWELL-PARKER ELECTRIC CO.

CLEVELAND, OHIO

Lucian C. and G. W. Brown, General Sales Agents, 50 Church Street, New York City

DISTRICT SALES AGENTS

F. W. Ward	Jos. M. Brown
1401 Park Bldg., Pittsburg, Pa.	31 W. Kinzie Street, Chicago, Ill.

MANUFACTURERS OF BUCKWALTER ELECTRIC TRUCKS

ECONOMICAL FREIGHT HANDLING

As fairly representative, the following average results have been extracted from records obtained during one month's operation of two out of a number of our freight car trucks owned and operated by one of the leading railroads in the United States, handling miscellaneous freight.

Monthly Totals

Total number of:		Total number of:	
days operated	26	tons handled	5,850
hours operated	286	loads carried	5,980
miles run	353.6	pieces handled	170,000

Daily Averages

Number of hours in service	11	Time running per load, sec.	59
Daily mileage	13.6	Time per load, min.	2.89
Per day tonnage	225	Time to load, sec.	58
Per hour tonnage	20.4	Time to unload, sec.	60.3
Number of loads	230	Number of men in gang	8
Length of haul in feet	158.5	Wages per man, tonnage basis	$2.40
Number of pieces per load	30	Ampere hour charge	160

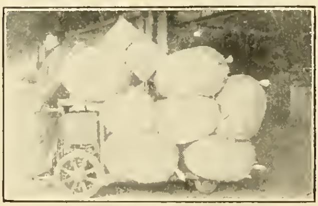
Summary

$.087 cost per ton for Labor
.0039 cost per ton for Power
.0033 cost per ton for Maintenance
.0099 cost per ton for Interest, Depreciation, etc.

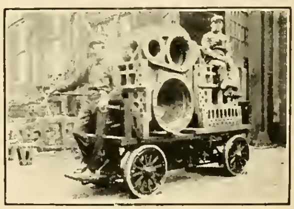
.1041 total cost per ton for Freight Handled.

RAILROAD FREIGHT TRUCKS

The following illustrations show two of our various types:



Freight Car Truck



Warehouse Truck

General Specifications—Freight Car Truck

Capacity	4,000 pounds	Height floor to lower platform	10¾ in.
Speed, empty	7 to 8 M.P.H.	Height floor to upper platform	3 ft. 9½ in.
Speed, loaded	5 to 6 M.P.H.	Height over stakes	3 feet
Weight, with lead battery	1,900 pounds	Width over body, motor end	42 inches
Weight, with Edison battery	1,750 pounds	Width over body, rear end	36 inches
Length over body	7 feet		

General Specifications—Warehouse Truck

Capacity	4,000 pounds	Height, floor to upper platform	3 ft. 9½ in.
Speed, empty	7 to 8 M.P.H.	Height, floor to lower platform	1 ft. 4¾ in.
Speed, loaded	4 to 5 M.P.H.	Height over stakes	48 inches
Weight, with lead battery	1,900 pounds	Width over body, motor end	3 ft. 2 in.
Weight, with Edison battery	1,600 pounds	Width over body, rear end	3 ft. 1 in.
Length over body	10 ft. 2 in.	Width over hubs	39 inches

THE RAIL JOINT COMPANY

GENERAL OFFICES:

185 MADISON AVENUE, - NEW YORK CITY

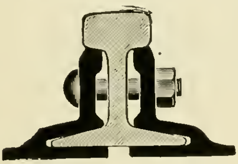
Catalog at Agencies

Boston, Mass. Pittsburg, Pa.
Chicago, Ill. Portland, Oregon
Denver, Colo. St. Louis, Mo.
Troy, N. Y.

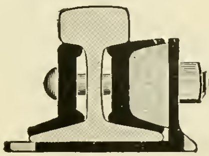
London, E. C., Eng. Montreal, Can.

MAKERS OF BASE-SUPPORTED RAIL JOINTS FOR STANDARD AND SPECIAL RAIL SECTIONS, ALSO GIRDER, STEP OR COMPROMISE, FROG AND SWITCH, AND INSULATED RAIL JOINTS, PROTECTED BY PATENTS.

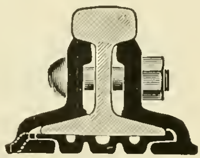
Highest Awards—Paris, 1900; Buffalo, 1901; St. Louis, 1904.



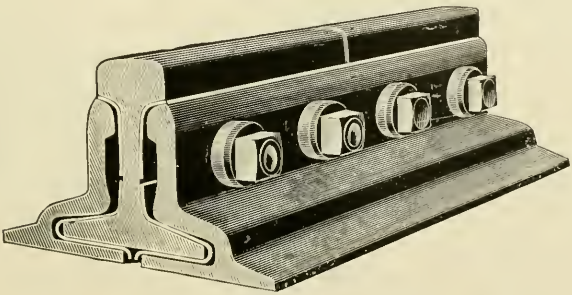
Continuous Joint



Weber Joint

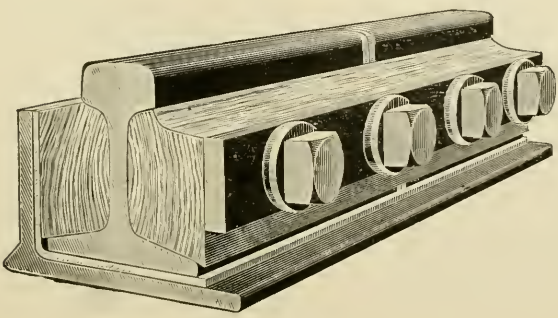


Wolhaupter Joint



Continuous Insulated Joint

Over 50,000 miles in use



Weber Insulated Joint

Rolled from Best Quality Steel

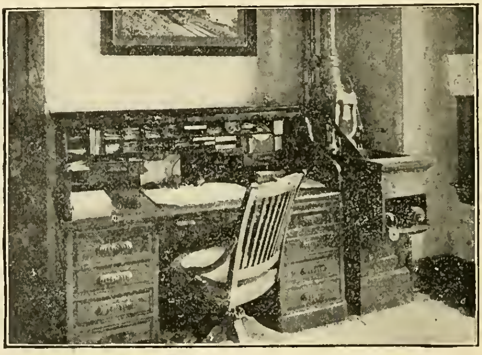
THE LAMSON COMPANY

BOSTON, MASS., U. S. A.

PNEUMATIC TUBES—CASH, PARCEL, MESSAGE, AND MAIL CARRIERS; AUTOMATIC, SWEEP-OFF, PICKUP AND SELECTIVE CARRIERS; BELT CONVEYORS, TRAY CONVEYORS, SMALL LIFTS, ELEVATORS, ETC.

PNEUMATIC DESPATCH TUBES

Designed and installed for all Office, Factory, Warehouse, Postal or Store Service requirements. Vacuum, Pressure, Vacuo-Pressure, Unit, "Two-way," Shifting Current or "Steam-jet" types in sizes of tubes ranging from 2¼ in. to 8 in. diameter. Latest Power-saving inventions. Over 50,000 stations of Lamson Tubes in use.

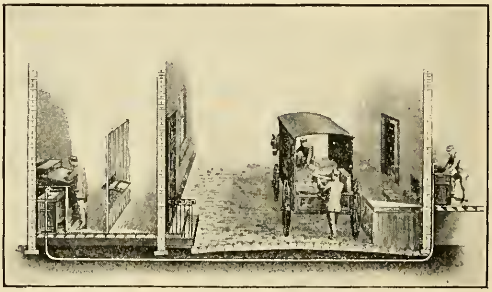


Desk Station 4" Mail Tubes in Private Office

FOOT POWER PNEUMATIC TUBES

No power plant required, operated by foot pressure. Efficient for lines up to 200 feet in length. Speaking tube attachments at small additional cost.

Sizes 2¼ and 3 inch O. D



Carrying Documents Between Buildings

SELECTIVE CARRIERS

Entirely automatic — pick up a load at any point and deliver it at any desired station.

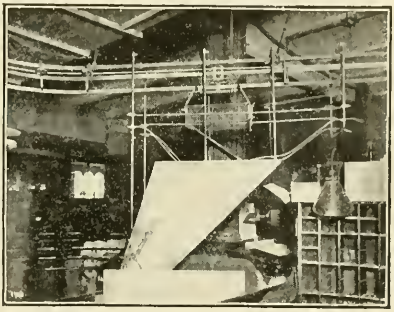
Made in any size to meet requirements—from carrying single sheets of paper to heavy bags of mail.

Automatic Mail Bag Carriers

THE LAMSON COMPANY

AUTOMATIC SWEEP-OFF AND DELIVERY CARRIERS

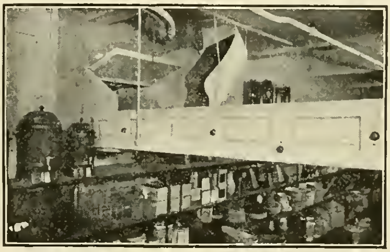
Constantly moving Baskets traveling on circuit lines and arranged to Sweep off Mail, Documents or Parcels from shelves and dump them into receiving chutes at required Receiving Stations. Made in Standard sizes as used by U. S. and Foreign Post Offices, or to Specifications.



Lamson Sweep-off and Dump Carriers for Post Office Work

LAMSON BELT AND TRAY CONVEYORS

All sizes for all conditions of Mail, Merchandise or Parcel Carrying. Special Conveyor Belts to carry Trays are built with Arresting Stations by which a constant supply of material is automatically maintained at each Station. Particular attention to complete Belt Conveyor Systems for assembly of "Send," "C.O.D." and "Transfer" Parcels in large Department Stores.



Store Service Belt Conveyor and Chute Showing Self-closing Fire Door

PICK-UP AND DELIVERY CARRIERS

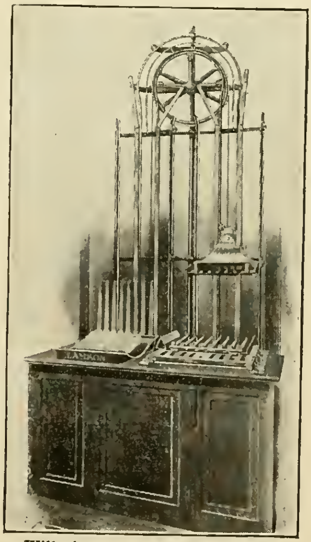
Constantly moving metal "fingers" that noiselessly pick up documents or small articles from one tray or station and deliver them at another as desired. Made in standard sizes to meet special requirements.

SPECIAL CONVEYORS

Made to meet any demand for assembly and distribution of Mail or Merchandise within or between buildings.

Plans and Estimates Free.

Representatives in all Principal Cities.



Will pick up at any station and deliver at any other station

ALPHABETICAL INDEX TO CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS